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FINAL

ENVIRONMENTAL IMPACT STATEMENT

BEACH EROSION CONTROL AND HURRICANE SURGE PROTECTION PROJECT

DADE COUNTY, FLORIDA

Prepared by
U. S. Army Engineer District, Jacksonville
Jacksonville, Florida

April 1975

Revised December 1975

SUMMARY

FINAL ENVIRONMENTAL IMPACT STATEMENT

BEACH EROSION CONTROL AND HURRICANE SURGE PROTECTION PROJECT
DADE COUNTY, FLORIDA

( ) Draft (X) Final Environmental Statement

Responsible Office: U. S. Army Engineer District, Jacksonville
P. O. Box 4970, Jacksonville, Florida 32201 Area Code 904-791-2241

1. Name of action. (X) Administrative ( ) Legislative

2. Description of action. The 10.5-mile Dade County, Florida, Beach Erosion Control and Hurricane Protection Project area will be partially restored to provide a recreational and protective beach. Proposed borrow areas are about 3,500 yards offshore throughout the project area in 40 to 60 feet of water. A section of the authorized project, a reach approximately 1.2 miles immediately south of Bakers Haulover Inlet in the northern portion of the project, is under contract by local interests and is the subject of a separate environmental impact statement filed with the Council on Environmental Quality.

3. a. Environmental impacts. About 14 million cubic yards of sand are to be dredged from ocean borrow areas and placed along the 9.3 miles of remaining project beach (10.5 miles, less 1.2 miles under separate contract) for restoration of the protective and recreational beach resource. Groins which now limit public use of the beach will be covered by the added sand, resulting in a broad, uninterrupted beach.

b. Adverse environmental effects. Organisms populating the borrow sites will be removed or driven from the sites. Motile invertebrates will begin to repopulate the sites after about 9 months. Silt and sediment suspended by dredging and by beach replenishment will cause turbidity over each section of the sequentially sectioned project length. The turbidity will be subjected to eddying and rotary currents and probably distributed over most of a section's area between beach and borrow sites.

Some of the scleractinian (hard coral) component of the reef community will be killed and the complex of plants and animals forming the community will change. Strictly reef-associated species of fish will be reduced in numbers as the reef habitat is reduced.

Those portions of the coral reef where colonies are killed will be subject to repopulation by neighboring coral colonies competing for the newly opened space.

4. Alternatives. Alternative plans considered to meet current and future recreational and protective beach needs were:

a. Further seaward extension of the sealing of the north jetty at Government Cut, which might benefit the beach north of the inlet and provide additional protection against shoaling of the channel. However, the low rate of littoral drift reaching the cut, the low shoaling rate in the cut, and the work done in 1959-1960 to make the north jetty sandtight for 450 feet make the additional extension unnecessary at this time. The environmental impact of this action would primarily involve the destruction of benthic organisms in the area of the extension.

b. Provision of a sand-transfer facility at Bakers Haulover Inlet, but littoral movement of material in the general area is insufficient to warrant such an installation. The environmental impact of this action would consist mainly of the destruction of benthic invertebrates in the immediate area of construction.

c. Filling in Bakers Haulover Inlet and removing the existing jetties; however, this would be detrimental to tidal circulation within Biscayne Bay and objectionable to boat owners. The environmental impacts of such action have not been assessed but could involve adverse effects on Biscayne Bay water quality and would result in loss of benthic invertebrates in the area of fill.

d. No action; this would not provide the additional recreational and protective beach desired by the local sponsor, and would permit further degradation of the project area as erosion continues. Various modifications of this alternative have been advanced. These involve abandonment of existing structures and land use practices to the actions of natural forces. These would result in losses in private and public investment and would not be compatible with the Flood Control Act of 13 August 1968.

5. Comments requested.

USDA - Soil Conservation Service
USDA - Forest Service
U. S. Department of Commerce
U. S. Coast Guard
U. S. Department of Interior
Environmental Protection Agency
U. S. Food and Drug Administration
Waterways Experiment Station
Department of Administration, Division of Planning
Fla. Dept. of Pollution Control
Fla. Dept. of Transportation
Fla. Dept. of Community Affairs
Fla. Dept. of Health and Rehabilitative Services
National Audubon Society
Tropical Audubon Society
Fla. Conservation Foundation, Inc.
Environmental Information Center

6. Draft statement filed with CEQ 15 September 1974.
Final statement filed with CEQ _____.

LIST OF APPENDIXES

Appendix No.	Title
A	Biological assessment of proposed offshore borrow area and reef communities, Dade County Beaches, Florida
B	Biological inventory relevant to the project
C	Allocation of costs and benefits
D	Recreation resources
E	Characteristics of littoral drift and of borrow materials
F	Letters to the District Engineer

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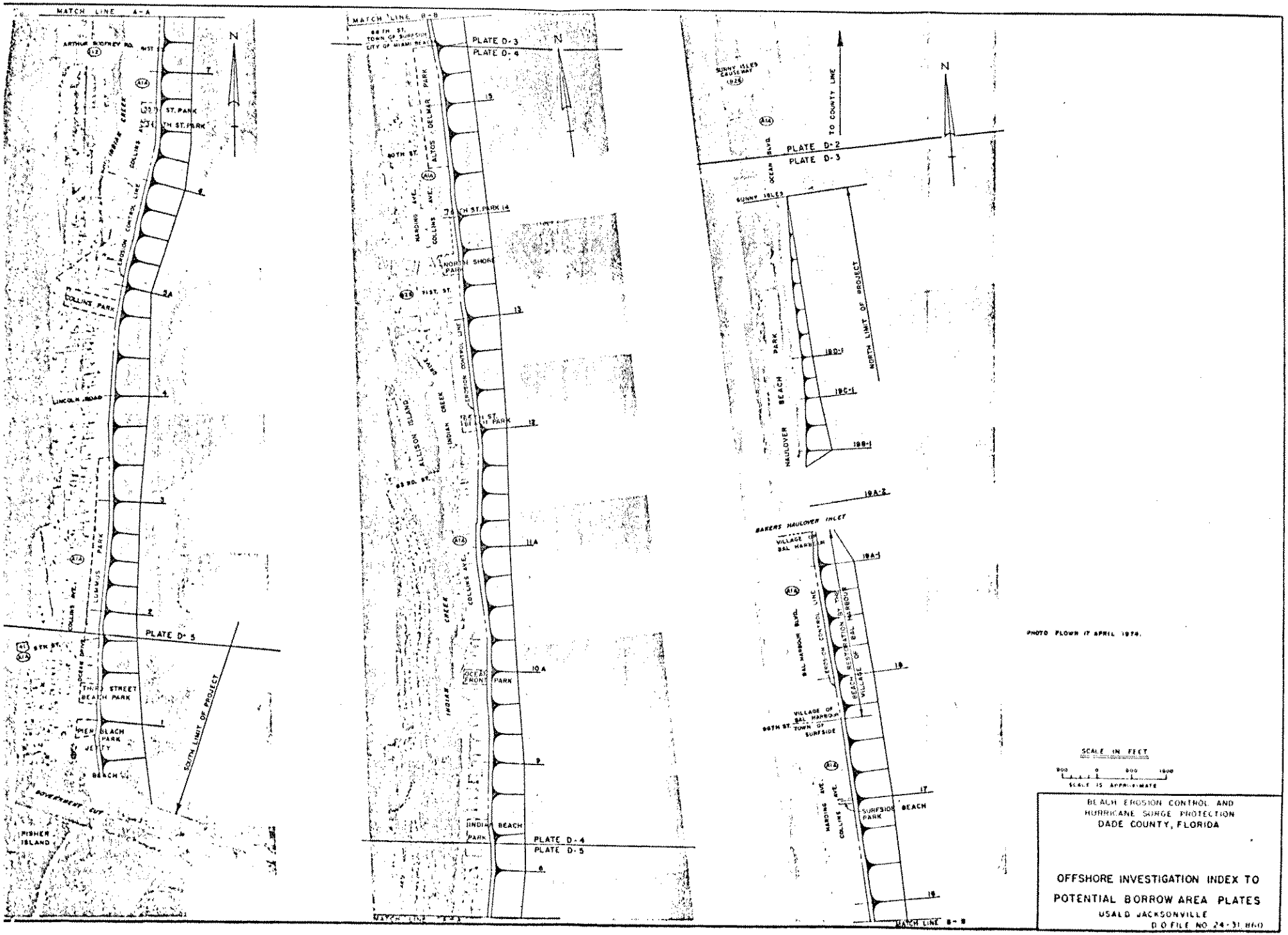
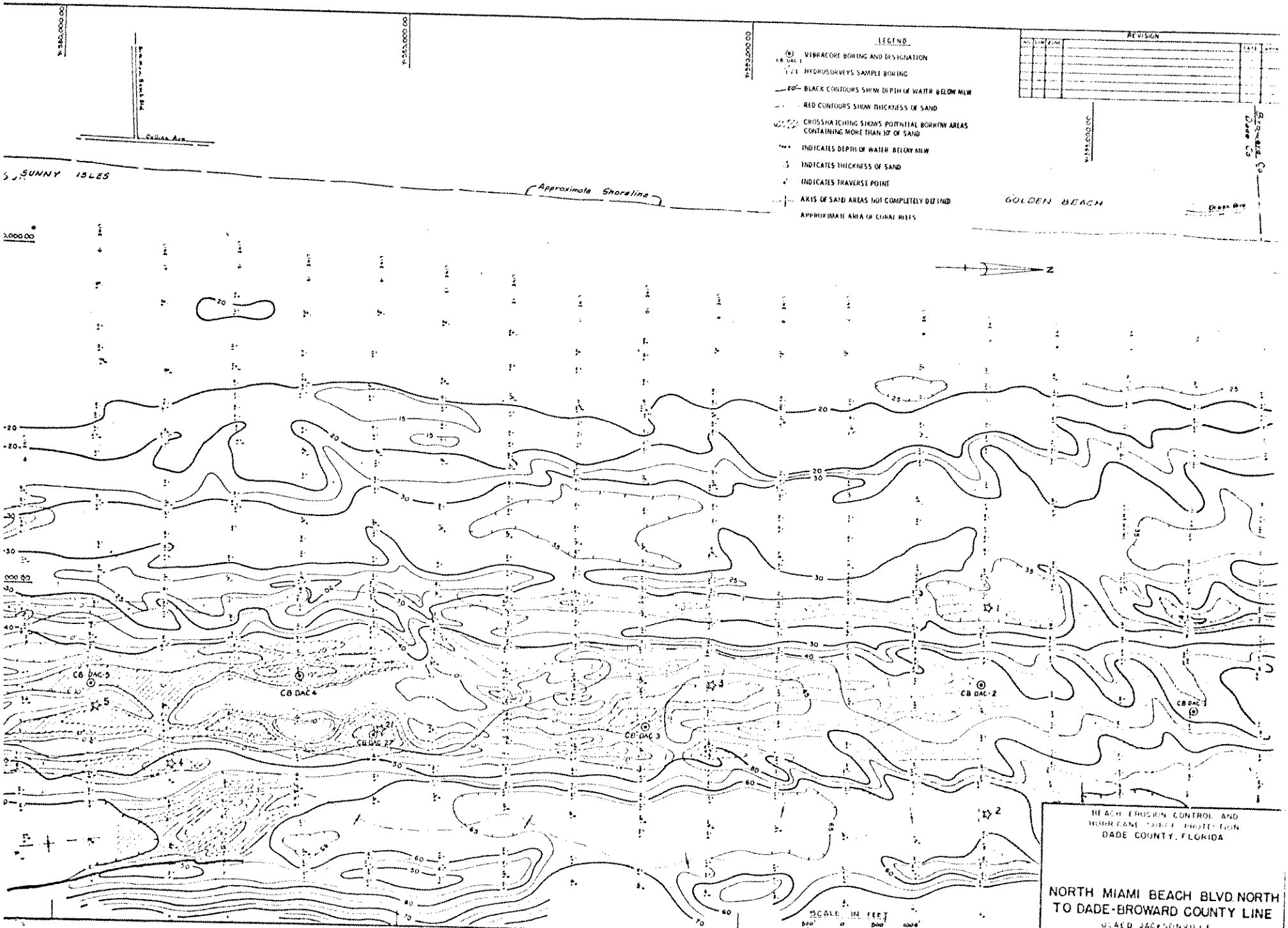


BEACH EROSION CONTROL AND HURRICANE SURGE PROTECTION
DADE COUNTY, FLORIDA

OFFSHORE INVESTIGATION INDEX TO POTENTIAL BORROW AREA PLATES

USAED JACKSONVILLE
D.O.FILE NO. 24-31-860

PLATE D1


LEGEND
VIBRACORE BORING AND DESIGNATION
HYDROSURVEYS SAMPLE BORING
BLACK CONTOURS SHOW DEPTH OF WATER BELOW MLW
RED CONTOURS SHOW THICKNESS OF SAND
CROSSHATCHING SHOWS POTENTIAL BORROW AREAS CONTAINING MORE THAN 30' OF SAND
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AXIS OF SAND AREAS NOT COMPLETELY OUTLINED
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SUNNY ISLES
Approximate Shoreline
GOLDEN BEACH
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Sunny Isles Blvd.
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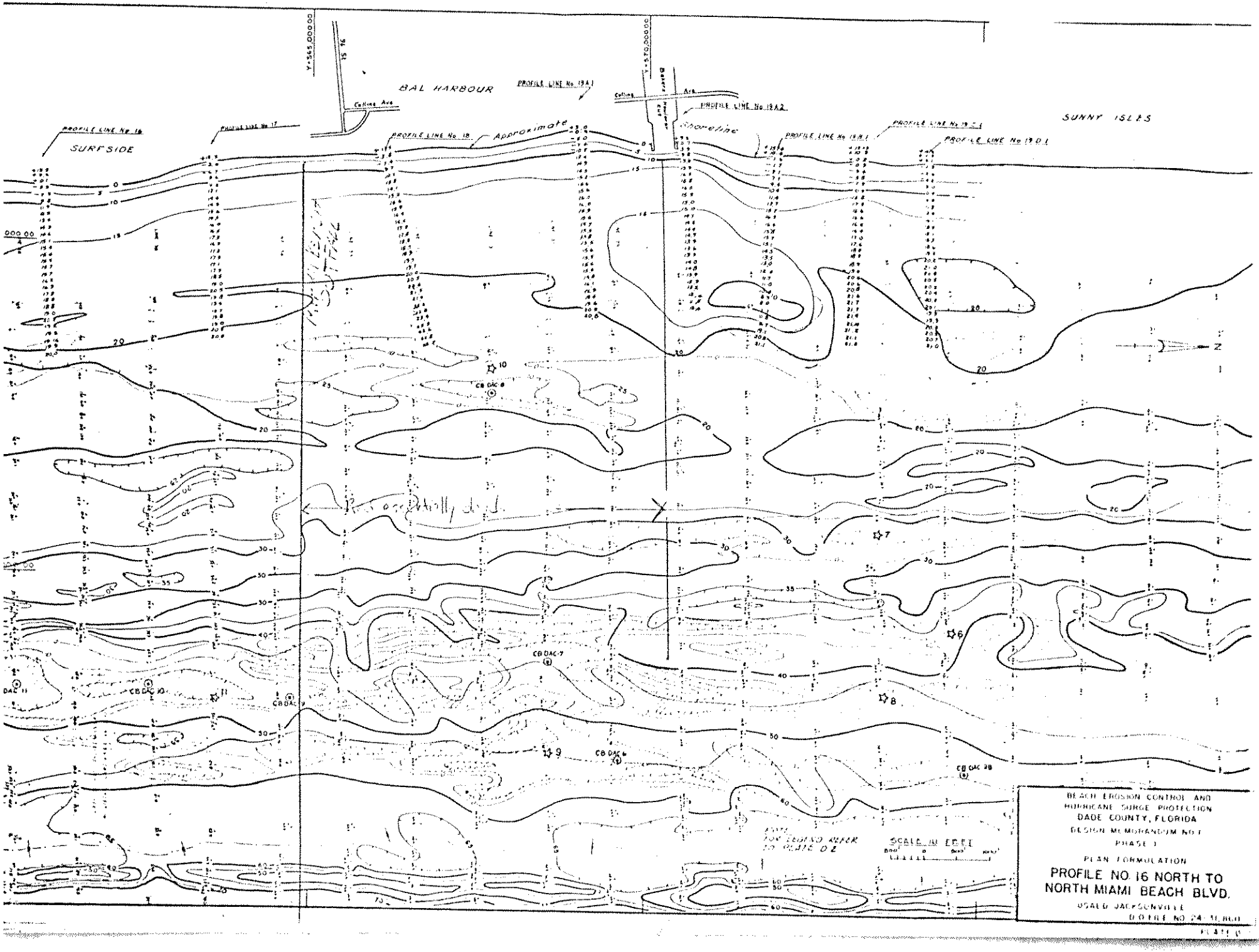
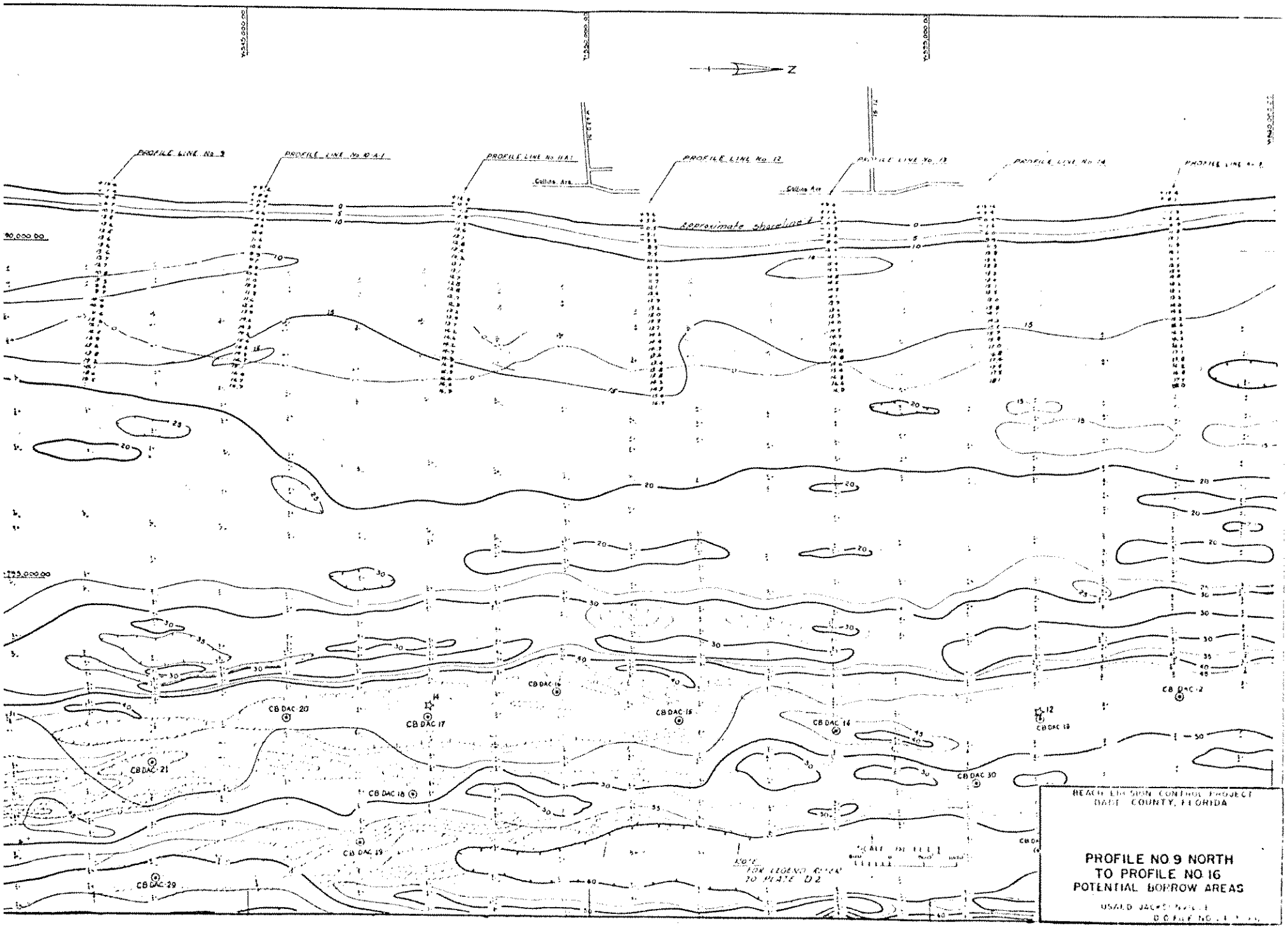
Ocean Blvd.
CB DAC 5
CB DAC 4
CB DAC 3
CB DAC 2
CB DAC 1
CB DAC 27
SCALE IN FEET
BEACH EROSION CONTROL AND HURRICANE SURGE PROTECTION
DADE COUNTY, FLORIDA
NORTH MIAMI BEACH BLVD. NORTH TO DADE-BROWARD COUNTY LINE
CORPS OF ENGINEERS JACKSONVILLE
DWG FILE NO 24-31 No.5
PLATE 2


BAL HARBOUR
SURFSIDE
SUNNY ISLES
PROFILE LINE No 16
PROFILE LINE No 17
PROFILE LINE No 18
PROFILE LINE No 19A1
PROFILE LINE No 19A2
PROFILE LINE No 19B1
PROFILE LINE No 19C1
PROFILE LINE No 19D1
Collins Ave.
Approximate Shoreline
CB DAC 8
CB DAC 7
CB DAC 6
CB DAC 9
CB DAC 10
CB DAC 11
CB DAC 9B
SCALE IN FEET
BEACH EROSION CONTROL AND HURRICANE SURGE PROTECTION
DADE COUNTY, FLORIDA
DESIGN MEMORANDUM NO 1
PHASE I
PLAN FORMULATION
PROFILE NO. 16 NORTH TO NORTH MIAMI BEACH BLVD.
CORPS OF ENGINEERS
DRAWING NO 24-16-80

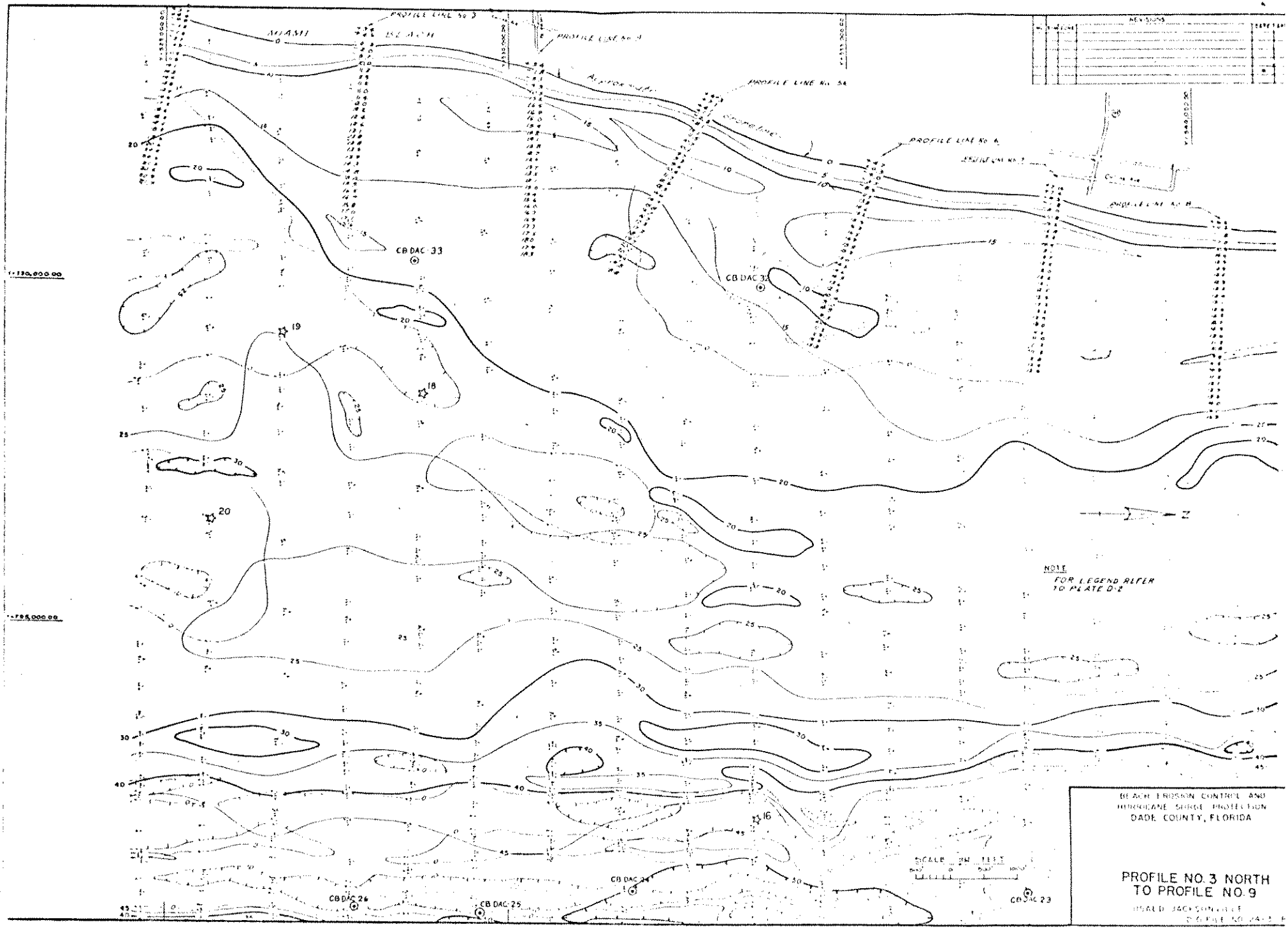


BEACH EROSION CONTROL PROJECT
DADE COUNTY, FLORIDA

PROFILE NO 9 NORTH TO PROFILE NO 16 POTENTIAL BORROW AREAS

USAED JACKSONVILLE
DRAWING NO. [illegible]

PLATE [illegible]



BEACH EROSION CONTROL AND HURRICANE SURGE PROTECTION
DADE COUNTY, FLORIDA

PROFILE NO. 3 NORTH TO PROFILE NO. 9

DUNCAN G. JACKSON, JR.
DISTRICT ENGINEER

h. Establish in public ownership for public use with acceptable access and necessary facilities all of the beach within project limits.

1.04 Portion under construction. Village officials of Bal Harbour, in view of advanced beach erosion and endangered seawalls, desired early construction of the 1.2-mile segment of the project beach immediately south of and adjacent to Bakers Haulover Inlet. That segment is now under contract and involves placement of initial fill amounting to 1,625,000 cubic yards and construction of five groins. A final environmental impact statement has been prepared on this portion and was filed 3 November 1972 with the Council on Environmental Quality.

2.00 Environmental setting without the project. The State of Florida occupies only a part of a much larger geographic unit, the Floridan Plateau. The deep water of the Gulf of Mexico is separated from the deep water in the Atlantic Ocean by a partially submerged platform nearly 500 miles long and about 250 to 450 miles wide. The plateau for many millions of years has been alternately dry land or covered by shallow seas.

2.01 The east coast of Florida from the Georgia line to Miami Beach, a distance of more than 350 miles, consists of a series of sandy barrier islands broken here and there by inlets. For the most part, the beach is rather straight. The Dade County shoreline, a barrier island with a lagoon behind it, is typical of a young shoreline. Prior to the recent emergence, the Dade County shoreline was inundated by the Pamlico Sea which left thin deposits of Pamlico sand lying unconformably over the widespread Miami Oolite.

2.02 The normal development for such beaches as those in Dade County would be for the shoreline or barrier bar to be moved back against the mainland. As the water is deepened in front of the bar, more direct wave action, especially during storms, is able to attack the bar, tending to move it shoreward.

2.03 The area is densely populated and probably represents one of the most thoroughly developed and heavily used resort areas in the world. The barrier strip varies in width from 0.2 mile to 1.5 miles and averages about 0.5 mile. Elevations of the strip range from about 5 to 10 feet, m.l.w. Higher elevations generally are along the oceanside where the average elevation is about 10 feet. The ground surface, in general, slopes down toward Biscayne Bay, a shallow sound about 38 miles long and from 3 to 9 miles wide with average natural depths of 6 to 10 feet. The bay is separated from the ocean by the narrow peninsula on which the project beach is located. The bay is connected to the ocean by two artificial cuts, Government Cut on the south end of the project reach and Bakers Haulover Inlet near the north end of the project.

2.04 The continental shelf narrows from 35 miles offshore at Cape Canaveral to four miles offshore at Miami Beach. The shelf is very rough and craggy through this area primarily because of a series of limestone coral and coral debris reefs dispersed between the shore line and the continental slope. From Cape Canaveral southward to West Palm Beach these reefs are widely separated and are erratic in form and occurrence.

2.05. From West Palm Beach to the Florida Keys there are three sharply defined series of reefs (Hoe, 1963). Goldberg (1973) has described this reef series as it appears offshore of Palm Beach County, Florida:

2.05.1 "These reefs are divided into three terraces. The first is closest to shore and forms a fairly well-developed back reef some 100 meters offshore in 4-5 meters of water in the Fort Lauderdale-Pompano Beach area. Off Boca Raton, however, the first reef is primarily littoral and is composed of calcarenitic beachrock, rather than coral limestone.

2.05.2 "A plain of gradually sloping sand lies between the first and second reef terraces. The latter develops relief of 2-3 meters and is composed of a broad platform of gorgonians and flat coral colonies. It lies in 7-8 meters depth and is approximately 800 meters offshore in the Fort Lauderdale-Pompano Beach area. A rocky ledge one or two meters high marks the seaward termination of this reef. The second reef off Boca Raton lies in 9-10 meters depth and is composed mainly of a line of flat patch reefs of variable sizes. In all patches observed this far north, the substrate rises scarcely more than 0.3 to 0.6 meter above the sand flats. In this paper, the term back reef will refer to both the first and second reef terraces.

2.05.3 "The second terrace is separated from the third by a sand depression which slopes to a depth of 17-19 meters. At this point it is abruptly terminated in most areas by a sheer rocky ledge 3-4 meters high. The top of the ledge marks the crest of the third reef, which generally lies in 16-18 meters of water. The reef which begins here is biologically and geologically the most well developed of all the terraces and extends to a depth of 30-40 meters. The outer reef can be divided into two subareas. The first is termed the outer reef platform because of its low relief and gradual slope. The platform extends to a depth of about 20 meters. At this point the terrain becomes rugged, forming knolls. In many localities

these fuse into spurs, some of which attain heights of over 8 meters. These areas of relief are separated from one another by sand or rubble-filled grooves, which are oriented in an east-west direction. This region slopes more rapidly into deeper water and is termed the out reef slope.

2.05.4 "The outer reef terminates in some areas by forming progressively smaller knolls or spurs, while in other regions the framework has a definite seaward limit. In either case, at a depth of 30-40 meters the terrain is composed of a flat plain of rubble. This marks the fore-reef region, which extends to a depth of at least 50 meters." (Goldberg, 1973; pp. 467-468)

2.06 Twenty-seven species of scleractinian corals and 39 species of gorgonians are found on these reefs as far north as Boca Raton and constitute a typical coral-reef community farther north than such communities are generally known to occur (Goldberg, 1973). A mean density of 25.1 colonies/m^2 on these reefs represents the highest concentrations of gorgonians recorded in the Caribbean region (Ibid.). North of the project area and presumably in the project area, especially on the outer reef, the large star coral (Monastrea cavernosa) assumes dominance over the common star coral (M. annularis). This relationship is characteristic of nonoptimal outer-reef situations, such as on the turbid windward reefs of Barbados, the reefs of southern Bermuda, and Brazilian reefs. The determinant is a low level of illumination caused in these cases by a high degree of turbidity (Ibid.).

2.07 Population trends. Dade County had a 1970 population of 1,267,792, a 29 percent increase over the 1960 population of 935,047. The 1974 population is estimated to be 1.4 million, and is forecast to be about 3.8 million by the year 2030 (Miami Beach Chamber of Commerce, undated).

2.08 Tourism. The tourist population is forecast to be 1 to 2.5 times the resident population throughout the 50-year life of the project works. Dade County beaches are basic to the local economy as tourist attractions and as a recreational resource for the resident population. Attendance at public beaches in Dade County north of Government Cut in 1961 was around 8 million visitor days. In 1973 nearly 13 million visitor days were estimated, and by the year 2030, an annual attendance exceeding 18 million visitor days is expected. Estimated total expenditure by tourists in Dade County in 1972 was $627,500,000 (Miami Beach Chamber of Commerce).

2.09 Fishery. Dade County has the largest population and the largest fleet of private, party, and charter boats in the State (Moe, 1963; 1970).* There are three main passages to the Atlantic that are used by the party and charter boats: Bakers Haulover Cut, Government Cut, and around the tip of Key Biscayne. Most of the offshore fishing is done in areas close to these inlets. The extensive inland waters of Biscayne Bay are used by many private boats in the major portion of their fishing activity. The northern section of the offshore fishing grounds of Dade County are confined to a narrow strip along the coast with steep slopes and sharply defined reefs. The shoreline curves away from the edge of the continental shelf in the southern section and results in a shallower, more uniform submarine terrain with a precipitous slope on the offshore side. As one progresses southward, there is a greater amount of shallow reef area that can be fished.

2.10 Party boats that fish the northern areas employ drift fishing methods during the day and anchor in shallower areas on the night trips. Most party boats in the northern section make two half-day trips during the daylight hours and one four-hour trip at night. Party boats that fish the southern areas make only one eight-hour trip per day and fish the shallower bottoms for reef fish. Drift methods produce king mackerel, dolphin, and a scattering of bottom fish. Anchored boats produce a wide variety of bottom fishes, with snappers, groupers, and grunts predominating.

2.11 Charter boats are highly competitive in both soliciting customers and magnitude of catches. Fishing trips are mostly on a half-day basis although full day trips are desired by the operators of the vessels. Sailfish is the most desired, and thus the greatest portion of the fishing effort is spent searching for this fish. Many charter boats in this area are using large reels with heavy wire line and fishing at depths down to 600 feet in search of tilefish, large Warsaw grouper and large amberjack. This deep line fishing is practiced when the more conventional methods do not produce the well known game fishes of the area.

2.12 Private boats fish for bottom fishes more often than for surface fishes. Snappers are most desired followed by groupers, dolphin, and king mackerel. Many private boats sell a large percentage of their catch to fish houses, according to reports of fish dealers.

2.13 Dade County has very little commercial fishing. There are some part-time commercial operations and some seasonal fishing for the king mackerel but there is no full-time commercial hook and line fishery based in this county.

*Part of the discussion in this section is excerpted from these two references.

2.14 The county has a year-round sport fishing season. The months of greatest activity are February and March. There is a secondary peak of activity during July and August that rivals the winter peak, and, for a few boats, surpasses it. Ten and seven-tenths percent of the seasonal sport fishing in the State occurs in Dade County. Almost all of the sport fishing boats in Dade County remain throughout the year because of the year-round season and the residency required by the county.

2.15 Table 1 shows the results of a 1963 survey of seasonal fisherman effort in Dade County. Summing the total projected seasonal fishing effort from party and from charter boats (70,652 angler days) and multiplying by the average daily amount spent on the east coast by saltwater fishermen in 1965 ($5.92 per day) (Stroud, undated), produces the figure of $418,260 per annum. This is a conservative estimate of the annual value to Dade County of the offshore fishing areas.

2.16 Land and water uses. Land use in 80 percent of the project area is classified by the Florida Coastal Coordinating Council in the category of "Recreation, Tourism and Historical." Such use includes not only the public beach recreation but tourism-centered developments such as hotels, restaurants, and shops.

2.17 Twenty percent of the land in the project area is categorized as residential. Such use in the project area is devoted to multi-family complexes such as condominiums and apartments.

2.18 Water supply and quality. Water for municipal, industrial, irrigation, and domestic uses in the project area is principally groundwater. (U. S. EPA, 1973a). The groundwater resources of the region consist of the Biscayne Aquifer overlying the confined Floridan Aquifer (U.S. EPA, 1973b). The Biscayne Aquifer is composed of shallow

TABLE 1

Fishing Effort in Fisherman Days for the Months of Greatest Activity, Dade County[1]

Vessel		MONTHS												Total Projected Seasonal Fishing Effort	Total Boats Reporting	Maximum Number of Vessels
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.			
Commercial	Surface	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Bottom	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total Reported	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Projected	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Party	Surface	752	752	482	157	157	157	457	715	715	157	157	482	20560	-	-
	Bottom	772	772	472	157	157	727	813	813	157	157	157	682	23344	-	-
	Total Reported	1524	1524	954	314	314	884	1270	1528	872	314	314	1164	43904	5	20
	Projected	6096	6096	3816	1256	1256	3536	5080	6112	3488	1256	1256	4656	-	-	-
Charter	Surface	467	682	633	394	-	171	574	574	139	163	104	140	26267	-	-
	Bottom	20	25	25	4	-	-	-	-	-	-	-	-	481	-	-
	Total Reported	487	707	658	398	-	171	574	574	139	163	104	140	26748	16	104
	Projected	3166	4596	4278	2588	-	1112	3729	3729	904	1060	676	910	-	-	-

[1] From Moe, 1963. A Survey of Offshore Fishing in Florida.

layers of sand, shell, and limestone which extend from the land surface to a depth of about 30 feet near Lake Okeechobee and to a maximum depth of 400 feet near the coast. Except near the coast where salt water has intruded, the water contained in the Biscayne Aquifer is generally soft and low in total dissolved solids.

2.19 The aquifer is highly porous. About 97 percent of the water contained in the aquifer is derived from local rainfall either by direct percolation or by infiltration from canals. About 3 percent of the water in the Biscayne Aquifer is reusable water from septic tanks.

2.20 Saltwater intrusion is a serious threat to the potable water supply in the Biscayne Aquifer. Intrusion results both from lowering of the freshwater piezometric head through withdrawal of water from the Biscayne Aquifer and from excessive drainage. A contributing factor which increased the rate of severity of intrusion in southeast Florida in the past was the uncontrolled canals which allowed saltwater to penetrate inland and come into contact with fresh groundwater near the surface of the groundwater table. Since completion of saltwater barrier dams in 1956, the salt front has gradually been pushed seaward. Maintenance of a freshwater elevation at the dams of greater than five feet above mean sea level for an extended period of time should theoretically flush saltwater from the aquifer. The provision of an adequate water supply to maintain the required five-foot elevation is a primary function of the Everglades Conservation Areas. During periods of inadequate rainfall, stored water is released from the conservation areas and Lake Okeechobee to supply water use demands and to maintain required water depths in the coastal canals.

2.21 During periods of adequate or excessive rainfall, water is captured in Lake Okeechobee and in the conservation areas. Precipitation in excess of available storage capacity is discharged into the Atlantic Ocean or into Everglades National Park.

2.22 Present methods of waste disposal. Dade County is developing a comprehensive wastewater management plan, and has received a Federal matching grant to assist in the plan development. Until the plan is completed and implemented two sewage outfalls will continue to operate in the project area. Miami Beach discharged an average volume of 22 m.g.d. of untreated wastewater in 1971. Discharge was through a 12,000-foot-long by 4-foot diameter conduit having a single port opening in 140 feet of water depth (U.S. EPA, 1973a). North Miami sewage, after communition and skimming, was discharged at the average rate of 25 m.g.d. in 1971, through a 10,000-foot-long, 4-foot diameter conduit into water 65 feet deep (Ibid.).

2.23 The Metropolitan Dade County Planning Department has proposed a management system which will ultimately divide the county into four regional collection districts. Each district will be served by a regional collection and treatment facility. Effluent from these regional facilities is expected to meet Federal-State water quality standards, and management systems selected have been shown to be economical in design. The total fifty-year investment in collection, treatment, and disposal facilities for the proposed service areas is estimated to be $319.3 million.

2.24 Three of the four planned regional collection districts would be created initially: North Dade, Virginia Key, and South Dade. The fourth service district, West Dade, will be created by about 1985 when projected growth will warrant a separate treatment and disposal facility. The interim plan has received local, State, and Federal approval.

2.25 North Dade Service Area. The plan for the North Dade Service Area includes placing into operation by 1975 an 80-million gallon per day (m.g.d.) secondary treatment facility in the Interama Area. Effluent disposal would be via a new outfall (parallel to the existing North Miami outfall) into the Atlantic Ocean. In 1985, when wastewater volumes will exceed the design capacity of the facility, the service area is to be reduced by joining the westerly portion of the North District with the new West Dade Service Area.

2.26 Virginia Key Service Area. The size of the Virginia Key Service Area will slowly decrease, generally in proportion to the projected increase in population density in outlying parts of the county. During this period, the direction of wastewater flow would be reversed in interceptors in some fringe areas of the service region, and would be pumped out of the district for treatment at the South Dade treatment plant (until 1985) or the West Dade plant (after 1985). The present Virginia Key treatment facility would be expanded and upgraded to secondary treatment to accomodate approximately 110 m.g.d. Effluent disposal would be accomplished through an extension of the existing Virginia Key outfall. The plant expansion and outfall extension is scheduled for completion by 1975 and 1977, respectively.

2.27 South Dade Service Area. The area proposed for service by the South Dade System will expand during the period 1973-1985 to encompass portions initially served by the Virginia Key system. After 1985, the service area will return to the smaller 1972 configuration, with a significant portion of the South Dade Service Area being incorporated into the newly created West Dade district. The quantity of wastewater received at the South Dade treatment facility will increase from an initial volume of about 12 m.g.d., after completion in 1975, to a maximum capacity of 50 m.g.d by 1985. In 1985,

approximately half of the flow from the plant would be diverted to the West Dade district; the remaining capacity would be made available for growth in the South Dade area. A predicted maximum capacity will be reached by the year 2000.

2.28 To accommodate wastewater collection in the South Dade area, a 50 m.g.d. secondary treatment plant is planned for construction in the Goulds-Perrine area. Effluent would be disposed of by deep well injection to the "boulder zone" of the Floridan Aquifer. The treatment facility and the deep well injection system are currently scheduled for completion by 1975.

2.29 West Dade Service Area. At present, the western portion of Dade County is sparsely populated, making immediate collection and treatment of present waste sources economically infeasible. Additionally, immediate sewering in this largely undeveloped region would encourage premature development and conflict with environmental planning goals. However, land use projections indicate that between the years 1975 and 1985 settlement of this area will have progressed to the point that a separate service area may be required in addition to the initial three proposed areas. Secondary facilities with effluent disposal by deep-well injection into the Floridan Aquifer are projected for construction in 1985 (U.S. EPA, 1973a).

2.30 Climatology. The project area is located in the subtropical portion of Florida and the climate is greatly influenced by the proximity of the Atlantic Ocean, the northward-flowing Florida current a short distance offshore and the easterly tradewinds which prevail much of the year. Winters are mild with temperatures averaging about 70 degrees F. Summer temperatures average about 80 degrees. The average annual temperature is about 75 degrees. Rainfall is relatively high, averaging between 50 and 60 inches per year. However, about 70 percent of the total rainfall occurs from June to October. Only about 10 percent falls from December through February. Weather Bureau records show that, on the average, southeast winds prevail in the project area about 28 percent of the time, easterly winds about 23 percent of the time, northeasterly about 17 percent of the time, with the remainder from other directions. The prevailing east and southeast winds are generally moderate and average about 10 m.p.h. The northeast winds generally are stronger and during the fall and winter months frequently occur during storms called "noreasters" which are considered highly damaging to the area beaches.

2.31 Hurricanes. Since 1830 a total of 48 tropical storms of various intensities have passed within 50 miles (considered the distance-limit of hurricane damage effects) of the project area. Of these storms, 26 were classified as hurricanes. The relative frequency of tropical storms in the area is once in every three years. The storms, which

can originate to the east in the Atlantic Ocean, to the south in the Caribbean Sea, or to the west in the Gulf of Mexico, usually occur during the period of June to November. Practically all of the project area is subject to flooding from tides and wave runup along the oceanfront during a hurricane. Damage to property, in view of the highly developed character of the area, can be extensive and severe. Accurate data on past hurricane-caused flooding of the project area are difficult to obtain due to conflicting reports but it is estimated that average annual losses from flooding from both the bay and the ocean sides are nearly $1 million. While hurricanes and tropical storms are a factor in the beach erosion problem in the project area, they are not considered as damaging as the frequent northeast storms which attack the Florida coast during the fall and winter months. These "noreasters" reportedly cause more erosion to the beaches in 2 or 3 months than is caused by winds and swells from other directions during the rest of the year. The storms are caused by a stationary high pressure front situated north of a low pressure front and can persist for 2 to 3 days. When a storm occurs when the moon is in perigee, abnormally high tides are generated. This, in combination with waves caused by storm winds, can have a destructive effect on the beaches.

2.32 Transportation. A transportation hub, Metropolitan Dade County is served by railroads, principal highways, including interstate routes, the Intracoastal Waterway, Miami Harbor (which handles international and coastal cargo and passengers), major airlines, cruise ship lines, and interstate buslines.

2.33 Federal projects in the area. There are three Corps projects in the study area of the proposed project. They are the Intracoastal Waterway, Miami Harbor, and Bakers Haulover Inlet. These projects are described in detail in the following paragraphs.

2.33.1 The Intracoastal Waterway from Jacksonville to Miami, a Federal navigation project, traverses the entire study area at distances from the shoreline ranging from 0.3 to 3.3 miles. The existing project dimensions in Dade County are 10 by 125 feet. The waterway runs along a series of small, manmade lakes at the north end of the study area, crosses Dumfoundling Bay, and enters the north end of Biscayne Bay at a point about 4 miles south of the Dade-Broward County line.

2.33.2 Miami Harbor. The Federal project of Miami Harbor extends from the ocean entrance to Government Cut westerly 5-1/2 miles across Biscayne Bay to the mainland. The project provides for the following:

(a) A channel 30 feet deep and 500 feet wide from the ocean to near the outer end of the north jetty, thence 30 feet deep and 400 feet wide through the entrance cut and across Biscayne Bay to and including a turning basin in front of the municipal terminals at Miami,

1,700 feet by 1,650 feet and 30 feet deep, and a turning basin along the north side of Fisher Island about 39 acres in extent and 30 feet deep; two parallel rubblestone jetties at the entrance, 1,000 feet apart and 3,000 and 2,750 feet long, and rubblestone revetment on both sides of the 1,000-foot-wide entrance cut. The part of the previous project completed in 1939 was essentially like the existing project except that the 400-foot-wide channel was only 300 feet wide, the turning basin at the municipal terminal was 1,400 feet by 1,350 feet, and there was no turning basin along Fisher Island. The additional work authorized by the existing project was completed in October 1964.

(b) A channel 15 feet deep and 200 feet wide from the mouth of Miami River to the turning basin at the municipal terminals; channel 8 feet deep and 200 feet wide, from the mouth of Miami River to the Intracoastal Waterway and thence 100 feet wide easterly to the entrance cut. The authorized work described in this subparagraph has not been accomplished.

(c) A Corps of Engineers survey-review report, authorized by the River and Harbor Act of 13 August 1968, has proposed modifying the Federal Miami Harbor project by deepening the existing bar channel to 38 feet, widening the north side of the channel between the jetties to 500 feet, deepening the entrance channel to 38 feet to the existing beach line, deepening the channel across Biscayne Bay to 36 feet, and deepening the turning basins at Biscayne Boulevard and Fisher Island to 36 feet.

2.33.3 Bakers Haulover Inlet is an artificial cut across the barrier beach between the Atlantic Ocean and northern Biscayne Bay. The inlet was constructed by local interests in 1925. The inlet, as originally constructed, was about 1,100 feet long, 300 feet wide at the ocean end between two short jetties, and 500 feet wide in the landward part. The change in width occurred abruptly about 260 feet from the shoreward end of the jetties. Originally the parallel ocean jetties, sand-filled steel cells, were 150 feet long. Controlling depths were about 16 feet between and seaward of the jetties, and 14 feet in the inlet proper. Dredging in Biscayne Bay for land fill has provided a channel at least 9 feet deep and 200 feet wide, from the inner end of the inlet northward about 2,000 feet to the Intracoastal Waterway. A swash channel normally about 5 by 200 feet leads southward from the inner end of the inlet. Tidal currents have formed a middle-ground shoal west of the inlet.

2.34 A project for improvement of the inlet was authorized by Congress in 1960. The project provides for a channel 11 by 200 feet in the ocean entrance, thence 8 by 100 feet to the Intracoastal Waterway; a marina basin 8 by 200 feet; and reconstruction of the jetties and

protection of the inlet shores seaward of the existing 500-foot-wide section. Reconstruction of the north jetty and provision of authorized revetment on the north side of the inlet were completed during the period June 17, 1963, to November 7, 1963. Construction of the relocated south jetty and revetment was completed in December 1964. In that segment of the proposed project now underway at Bal Harbour by local interests, work includes extension of the south jetty.

2.35 Publicly owned shorefront property. The Corps of Engineers owns 400 feet of shore frontage at the south end of the study area, contiguous to Government Cut. The Miami Beach Resident Office occupies most of the parcel, which extends from the ocean to the landside of the cut. Parts of the parcel are occupied under lease by the city of Miami Beach and the Miami Bar Pilots Association. The average depth of the parcel is about 1,600 feet. Erosion has never been a problem as the parcel is located in the impoundment fillet of the north jetty at Government Cut.

2.36 Non-Federal publicly owned shore frontage includes the following sites (ends of public streets leading to and ending at the shoreline are included as public beaches):

2.36.1 Jetty Beach - a bathing beach at the southernmost tip of Miami Beach. Shore frontage, 1,200 feet.

2.36.2 Pier Park - a bathing beach about 0.3 mile north of Government Cut. Shore frontage, 300 feet.

2.36.3 3rd Street Beach - a bathing beach about 0.5 mile north of Government Cut. Shore frontage, 500 feet.

2.36.4 Lummus Park - a major bathing beach and park about one mile north of Government Cut. Shore frontage, 4,000 feet.

2.36.5 Collins Park - a bathing beach about 0.4 mile north of Lincoln Road in Miami Beach. Shore frontage, 400 feet.

2.36.6 Indian Beach Park - a bathing beach about 0.5 mile north of Arthur Godfrey Road in Miami Beach. Shore frontage, 600 feet.

2.36.7 65th Street Beach - a bathing beach about 1.7 miles south of the north city limit of Miami Beach. Shore frontage, 400 feet.

2.36.8 Northshore Park - a bathing beach and recreation area about 1 mile south of the north city limit of Miami Beach. Shore frontage, 1,400 feet.

2.36.9 Altos Del Mar Park - a bathing beach about 0.4 mile south of north city limit of Miami Beach. Shore frontage, 700 feet.

2.36.10 Surfside Beach - a bathing beach and recreation area at the town of Surfside. Shore frontage, 110 feet.

2.36.11 Haulover Beach Park - a major bathing beach and park occupying the entire barrier strip immediately north of Bakers Haulover Inlet. Shore frontage, 7,100 feet.

2.36.12 Sunny Isles Beach - a bathing beach at the end of Sunny Isles Causeway. Shore frontage, 475 feet.

2.36.13 Golden Beach - a bathing beach for the use of the residents of Golden Beach only. Shore frontage, 150 feet.

2.36.14 Between Government Cut and Bakers Haulover Inlet there are 47 street ends available as bathing beaches. Shore frontage, 2,360 feet.

2.36.15 Between Bakers Haulover Inlet and the north county line there is one street end available as a bathing beach. Shore frontage, 80 feet.

2.37 The total ocean shoreline in public ownership, including 400 feet Federally owned, is 11,970 feet, or approximately 2.3 miles, between Government Cut and Bakers Haulover Inlet. The total ocean shoreline in public ownership between Bakers Haulover Inlet and the north Dade County line is 7,805 feet, or approximately 1.5 miles, most of which is in Haulover Beach Park.

2.38 Public access. In Florida, title to riparian property extends to the mean or ordinary high-water line. Seaward of that line the beach and submerged bottom lands are in custody of the Trustees of the Internal Improvement Fund, a State body, to be held in trust for the benefit of the people of the State. Technically, therefore, the public may not be deprived of access to the beach below the mean high water line, except by such lawful regulation as may be imposed in the interest of the public. However, in the study area, the concentration and the character of the numerous groins and seawalls which have been constructed generally prohibit the public from using the beach in front of private property. Extended movement along the beach in a north-south direction is all but impossible. Therefore, as a rule, the general public has access to the ocean only where the shore front is publicly owned.

2.39 Geological investigations performed.

2.39.1 Prior investigations by the Coastal Engineering Research Center (CERC). In 1965 CERC conducted a program of mapping sand deposits suitable for beach restoration. The work, known as the Inner Continental Shelf Sediment and Structure Program, included Florida's coastal waters. Seismic reflection profiling was used along grid lines to delineate structures and bedding planes in sea floor sediments. Precision radar was used for positing. By interpretation of the siesmic reflection records, the character of sea bottom materials was inferred. By taking core samples of the sea bottom materials to supplement the seismic profiles, general areas of suitable material for beach restoration were established. The study results, published in bulletin CERC-TM-29, November 1969, indicate a sand source in Dade County located about 3 miles offshore between two reefs in 30 to 60 feet of water.

2.39.2 Investigations by the Jacksonville District. In order to obtain more detailed information on a source of sand for Dade County Beaches, the Corps of Engineers conducted additional studies in 1974. The Corps investigation, guided by the results of the CERC study, extended from the southern tip of Miami Beach northward to the Dade-Broward County line. The investigation included beach profile lines, aerial photography, geophysical exploration and core drilling.

2.39.3 Littoral drift material. In March 1974, the Corps of Engineers personnel surveyed 24 profile lines from the beach bulkhead or dune crest seaward for 3,000 feet. Along 8 of the profile lines, surface samples of the beach sand were collected from the dune line, at mean high water, mean low water, and elevation -5 feet for grain size analysis. The sample test results are presented in appendix E.

2.39.4 Aerial photographs. Uncontrolled aerial photography, consisting of standard 9" x 9" photos with a scale of 1:9,600 was flown over the beach and offshore study area.

2.39.5 Geophysics. The geophysical exploration included subbottom profiling, hydrographic surveys and overburden sample collection. The work was performed in January 1974 by Hydrosurveys, Inc., Fort Lauderdale, Florida, under Professional Engineering Services Contract No. DACW17-74-C-0018.

2.39.6 Subbottom profiling. High resolution boomer-type geophysical equipment was used to take subbottom profiles along lines running east-west at approximately 1,000-foot stations. The area of investigation extended from 2,000 feet offshore east to the -60-foot mean low water contour line. The total amount of subbottom profiling was approximately 123 line miles.

2.39.7 Fathometer survey. Fathometer surveys were taken along the same lines and concurrent with the subbottom profiles. The fathometer was calibrated by bar check at the beginning and ending of each day's work. The fathometer sounding records were correlated with tide data to obtain correct bottom elevation. Electronic positioning equipment capable of preprogramming and shipboard plot tracking of the survey vessel's location was employed during the project. Field plot tracking to a scale of 1 inch equals 500 feet was employed along all required subbottom profile and fathometer survey lines.

2.39.8 Data reduction. Subbottom profile and fathometer survey records were reduced to reflect ocean bottom elevations and top of rock elevations. This information was plotted along the subbottom profile and fathometer survey lines to the nearest 0.1 foot in relation to elevation - mean low water. From this data, a map showing the contour of the ocean bottom, contours on top of rock, and an isopachous map overlay showing the thickness of overburden were prepared on a scale of 1 inch equals 500 feet. The maps are presented in appendix E.

2.39.9 Offshore overburden samples. Twenty samples representative of the full depth of overburden were obtained and the sample locations are shown in appendix E. Grain size gradation tests were run on each sample and the test results are included in appendix E.

2.39.10 Offshore core drilling. The final phase of the Corps investigation was a core drilling program to check out the potential sand borrow areas delineated by the geophysical survey. During May 1974, 32 core borings were drilled within the best potential source areas utilizing vibracore drilling methods. The vibracore produced 3-1/2 inch diameter core samples in 20-foot long clear plastic liners. The core drilling was done by Alpine Geophysical Associates, Inc., Norwood, New Jersey, under contract No. DACW17-74-C-0044. The borings were drilled to a depth of approximately 20 feet below the sea bottom or to rock if encountered at a lesser depth. A Corps of Engineers geologist was present aboard the drill boat to check the material as it was recovered. When full, the 20-foot sample tubes were cut in half for easier handling and the ends were sealed. Decca precision positioning equipment was used by the contractor to position the drill boat over the desired boring location (appendix E). The vibracore samples were shipped to the Corps of Engineers Dredge Depot in Jacksonville where they were split open and a detailed log prepared by a Corps geologist. The core logs are on file at the U. S. Army Engineer District, Jacksonville, Florida. Samples representative of the materials in each boring were sent to the SAD Laboratory for grain-size gradation tests. The test results are included in appendix E.

2.40 Offshore sediment deposits. The geophysical and sampling program delineated several potential sand borrow areas seaward from Miami Beach (appendix E). As indicated by the CERC report the potential borrow areas are trenches which run parallel to the shoreline 6,000 to 10,000 feet offshore. These trenches, filled with sand composed of quartz, shell, and coral fragments, vary from very narrow up to 1,000 feet or more in width and geophysical records indicate the depth of fill (sand) varies from a few feet to more than 40 feet.

2.41 Description of sediment deposits. The distribution of grain sizes naturally present on a stable beach represents a state of dynamic equilibrium between the supply and loss of material of each size. Coarser particles generally have a lower supply rate and a lower loss rate; fine particles are usually more abundant, but are rapidly moved alongshore and offshore. Where fill is to be placed on a natural beach that has been stable or only slowly receding, the size characteristics of the native material can be used to evaluate the suitability of potential borrow material. A borrow material with the same grain size distribution as the native material, or one slightly coarser, will usually be suitable for fill.

2.42 The proposed borrow sands generally have a high carbonate (shell) content. The sand size ranges from fine to coarse and some silty fines are generally present. Shells and gravel size to cobble size coral fragments are relatively common. The bulk of the sand falls in the fine to medium size range. The silty fines form a small percent of the total and are within acceptable limits. The quartz present usually is of fine grain size while the larger sizes are composed of locally derived shell and coral fragments. The sand sizes generally become finer grained in the deposits which lie farther from shore and in deeper water. The dredged sand will, however, be equal to or coarser than that presently on the beach.

2.43 The shell fragment portion of the sand is composed of fragments of mollusks, coral and foraminifera. The foraminifera fragments are delicate and when placed on the beach will, to some extent, disintegrate under the pounding of surf action. The mollusks and coral fragments are tougher and would be less susceptible to disintegration. Disintegration would probably not occur to such extent as to destroy the integrity of the material placed on the beach.

2.44 Volume of material. The extent of each potential borrow area was delineated in accordance with the geophysical data with a minimum width of 200 feet and a minimum depth of 8 to 10 feet as cutoff points. Plate 1 shows the potential borrow areas. For ease of operation it is expected that a contractor would choose the borrow areas

closest to shore and in water less than 30 feet deep as the primary borrow areas and then, if necessary, move to the more distant and deeper water areas.

2.45 Additional offshore investigations. Prior to dredging operations, it will be necessary to determine the location of living reefs, if present, and establish allowable limits for dredging. The most favorable potential borrow areas, which are chosen for use, will be more precisely delineated by additional geophysics and vibracore sampling. Accurate delineation of the borrow areas is necessary so the dredge can extract the sand from the relatively narrow troughs, and for protection of reef corals.

2.46 Swells. Because of the configuration and bearing of the shoreline in the study area, swells approaching from the north and northeast cause a southerly drift; swells from the southeast and south cause a northerly drift. Swells from the east approach the study area generally normal to the shoreline and probably create very little drift in either direction. Seasonally, the analysis of data for the study area indicates that during the months September through February the prevailing and predominant swells approach from directions which set up a southerly drift; during March, April, and May the resultant directions of drift are uncertain; and from June through August the prevailing and predominant directions of swell approach are such as to create northerly drift. Net littoral drift is therefore southerly as indicated by the small impoundment of sand at the north jetty of Government Cut and at various groins in the study area. The incidence of swells in the Miami Beach area is influenced by the shelter afforded by the islands of the Bahama group, which limit fetches to the east and southeast.

2.47 Waves. Records of waves in the Miami area are limited. The slope of the ocean bottom is somewhat flatter than at Palm Beach, so it can be expected that wave heights are somewhat less. Wave heights of 10 feet and periods of 4 to 18.9 seconds have been recorded in the ocean at Palm Beach.

2.48 Tides and currents. The mean range of tide in the Atlantic Ocean at Miami Beach is 2.5 feet; the spring range is 3.0 feet. The lowest tide to be expected is 1.4 feet below mean low water. Variations in water-surface elevations of more than 7 feet have resulted from storms. The maximum unofficial ocean tide of record at Miami Beach, 6.7 feet, occurred during the hurricane of September 1926. That value was a measured high-water mark just inside Government Cut. The second highest ocean tide of record at Miami Beach was 6.3 feet and occurred during the hurricane of October 1950. Maximum tidal current velocities through Government Cut are ordinarily about 5.5 feet a second on average tide, but occasional velocities of 6.2 feet a second have been recorded during spring tide.

2.49 Tides create swift currents through the narrow section of Bakers Haulover Inlet. A current velocity measurement survey made on September 4, 1952, showed an average velocity of 5.6 feet per second and a maximum of 9.2 feet per second. The survey was made during a 3.4-foot range of tide. Current velocity varies with the range of tide. The mean range near the inlet is 2.5 feet in the ocean and 2.5 feet in Biscayne Bay. According to Coast and Geodetic Survey Tables, maximum velocity of ordinary ebb tides through the inlet ranges from 2.2 to 4.6 miles per hour.

2.50 Offshore the tidal current is quite different from that found in inlets, bays, and rivers. In these inside waters a tidal current, as described above, is of the reversing type. It sets in one direction for a period of about 6 hours after which it ceases to flow momentarily and then sets in the opposite direction during the following 6 hours. Offshore the current, not being confined to a definite channel, changes its direction continually and never comes to a slack, so that in a tidal cycle of about 12.5 hours it will have set in all directions of the compass. This type of current is called a rotary current.* Wind tides accompanying severe storms induce currents of 7 to 8 miles an hour in part of the inlet. Ordinary ebb currents through the inlet meet incoming ocean waves and swells forcibly, thus setting up standing waves about 100 to 300 feet beyond the outer ends of the jetties. The standing waves are usually 3 to 4 feet high and often develop vertical faces which fold over or collapse towards shore. It is estimated that ebb-current mean velocities in excess of 2 miles an hour prevail about 35 percent of the time.

2.51 A current and sand movement study at Miami Beach by the Corps of Engineers in 1936 (H. Doc. 169, 75th Cong., 1st Sess.), showed that during calm weather with light southerly and easterly winds the bottom currents offshore seldom exceeded a velocity of 0.5 foot per second. The bottom currents offshore were generally from south to north and the longshore currents varied with the general directions of the wind. The longshore currents which were measured simultaneously with those offshore were generally weaker than those offshore. All current measurements for the study were made during comparatively calm weather between June 9 and July 9, 1936. Measurements showed an almost universal movement northward during this period. However, information available and evidence afforded by accumulation of sand on the north sides of jetties and protective works in the area indicate that the predominant net sand drift is from north to south.

*National Ocean Survey, NOAA, 1974, "Tidal Current Tables." p. 175.

2.52 The Florida Current, as the portion of the Gulf Stream flowing through the Florida Straits is called, varies from one-half mile to 15 miles offshore throughout this area. Thus the strongest, most consistent current is northward.

2.53 Southward flowing inshore currents are associated with cyclonic eddies of parcels of water from the northward flowing Florida Current. This conclusion is supported by biological evidence reported by de Sylva and Scotton (1972), and by their review of available information.

2.54 The aforementioned investigators collected 20 specimens of stomiatoid fish larvae (Bathophilus, Cyclothone, and Stomias) from Biscayne Bay. The adults are mesopelagic (deep-sea, mid-depth) in the water of the Florida Current and, therefore, these larvae were presumably transported in parcels of high salinity, offshore water into Biscayne Bay by winds, tides, or currents.

2.55 "The Florida Current moves northward with speeds up to 250cm/sec (8.2 ft./sec.) (Stewart et al., 1970). Hydrographic data and bathymetric measurements indicate that the Florida Current meanders westward to within about 6 km. (3.7 miles) of the shore (Wennekens, 1959; Stewart et al., 1970). As the Florida Current passes northward past Biscayne Bay, cyclonic eddies may spin off the western edge and be carried northward through the coastal waters, producing southward currents on the shelf (Mr. T. N. Lee, personal communication). Southward currents in nearshore waters off Pompano and Delray Beaches show consistently higher salinity than occurs when the coastal currents are to the north, due to the advection of water from the Florida Current by the eddies (Stewart, et al., 1970). Along the eastern shore of the barrier islands of Biscayne Bay, southward along-shore currents predominate from September through February (Wanless, 1969)." (de Sylva and Scotton, 1972.)

2.56 The authors hypothesized that sewage discharged through ocean outfalls to the north of Biscayne Bay into coastal waters and, purportedly, the Florida Current is recycled back into coastal waters and Biscayne Bay by the mechanism which may have carried the deep-sea larvae into the bay.

2.57 To summarize the foregoing:

2.57.1 The net southward alongshore movement of sand in the project area is counter to the northward flowing Florida Current, and is associated with eddies spinning off of the western edge of the Florida Current.

2.57.2 Substances in the western edge of the Florida Current and inshore from the current are probably not simply carried parallel to the shore but are circulated in eddies and currents and may be carried to the shore.

2.58 Existing erosion problem. A combination of factors, including prevailing winds, waves, swells, storms, beach development, littoral drift, protective structures, and the presence of artificial inlets, are causing serious beach erosion in the project area. Recreational beach has been lost, valuable beach property is threatened and seawalls have come under direct wave attack. At a number of locations, shorefront structures are undermined or threatened with undermining by erosion.

2.59 Previous work. Corrective action in the study area has been mostly limited to the installation of conventional shore-protection structures--seawalls, bulkheads, groins, and revetments. Such installations, especially of seawalls and groins, have been extensive. The shoreline of Dade County is almost a continuous line of seawalls with abutting groins. Two beach-nourishment fills were made by local interests in September 1960; about 86,000 cubic yards of sand were placed immediately south of Bakers Haulover Inlet at Bal Harbour, and about 180,000 cubic yards of sand were placed at Haulover Beach Park. Also, about 25,000 cubic yards of sand were added to the area south of the inlet in May 1961. A concrete-membrane, rubble-mound groin 140 feet long was installed by Dade County in 1960 about 300 feet south of the south jetty at Bakers Haulover Inlet. The groin was installed to assist in anchoring the beach fills deposited south of the inlet and to reduce the amount of material entering the inlet during flood tides and periods of drift reversal. The beach fills and the groin were within the area to be covered by the study approved by the Chief of Engineers on 24 May 1960, and were made subsequent to that date. In connection with prior corrective action, the north jetty at Government Cut, for a distance of several hundred feet from shore, was made essentially sandtight in 1959-1960.

2.60 Existing structures. Existing structures include the jetties at Government Cut, the jetties at Bakers Haulover Inlet, and the thousands of feet of seawalls and groins in between. At Government Cut there are two parallel rubble stone jetties, 1,000 feet apart, and 3,000 feet and 2,750 feet long. At Bakers Haulover Inlet the two parallel ocean jetties are of sand-filled steel-cell construction.

2.61 There are about 39,265 feet of seawalls fronting the ocean between Government Cut and Bakers Haulover Inlet, 20,925 feet of which have a wide protective beach, and 18,340 feet of which have little or no beach. The walls are of various types, heights, ages, conditions, and costs. Some of the existing walls were constructed by the city of Miami Beach in 1927 and 1930. The seawalls seem to have adequately served the purpose intended by the owners; that is, protection of upland property. Many of the walls, however, have water against them during normal tides, and are subjected to direct wave action at times.

2.62 The majority of groins on Miami Beach shoreline were constructed in 1927 and 1930 as part of the protective works program at that time. The groins installed in 1927 are generally 200 feet long and 300 feet apart. The groins built in 1930 are generally 170 feet long and 250 feet apart. All the groins constructed in 1927 and 1930 were of steel-sheet-pile and timber-bracing construction. Since 1930, many groins have been installed by private interests north and south of the original 1927-1930 installations. The condition of the groins in the reach varies from very poor to good. Although it is evident that the extensive groin systems in the area generally have not preserved or substantially added beaches, there is a strong feeling among many local residents that the condition of the beaches would be much worse without the groins than with them.

2.63 At present, there are about 12,470 feet of seawalls in the reach between the inlet and Broward County. There are primarily privately owned steel-sheet-pile walls with concrete cap. The walls in this reach are newer, higher, and generally in better condition than many of the walls in the southern reach. There are 55 timber groins in the reach. The groins are low (many observed to be below water at high tide) and short, with lengths generally ranging from 50 to 100 feet. The condition of the groins varies from good to very poor. Due to their short length, the groins appear to have little effect on shoreline behavior.

2.64 Shore processes. The beaches in Dade County are composed generally of fine sand and shell fragments. The sand and shell are easily moved by littoral currents and by wave action. Littoral drift is predominantly southward. The behavior of the shore is currently influenced by two inlets, Bakers Haulover and Government Cut. Bakers Haulover Inlet is protected by two short jetties, and Government Cut is protected by two long rubble-mound jetties that are essentially sand-tight near the shore. The inlets constitute partial littoral barriers. A general deficiency in supply of littoral material reaching the area, plus the action of littoral barriers, have resulted in severe erosion over parts of the study area.

2.65 Shoreline and offshore depth changes. Available data show that for the period 1867 to 1961, the emergent shoreline receded and advanced in almost equal distribution but for the last 40 years of that period much of the shoreline advance was accomplished by extensive seawall construction seaward of the shoreline with backfilling behind the wall. Significantly, data on offshore depth contours show that the 6-foot depth contour receded from 1919 to 1961. During that period, the 12-foot depth contour receded an average of about 282 feet for the reach between Government Cut and Bakers Haulover Inlet. Similar recessions occurred in the 18 foot and 30-foot depth contours. In general, there has been a steepening of the beach profiles in the project area.

2.66 Erosional rates. An analysis of the profile changes reflected in the surveys of 1919, 1927-1928, and 1961 was made during the 1964-1965 Cooperative Beach Erosion Control Study and Hurricane Protection Study of Dade County, Florida, from Government Cut to North County Line. The analysis showed that for the period 1919 to 1961, the average annual erosional rate for the reach between Government Cut and Bakers Haulover Inlet was 158,000 cubic yards.

2.67 Taking into account the material placed on the beach by local interests prior to the 1961 profile survey, the average annual erosion rate over the entire length of profiles becomes 161,000 cubic yards. The corresponding rates for the reach between Bakers Haulover Inlet and Broward County during the period 1927-1929 to 1961, are 128,000 cubic yards based on profile losses alone and 133,000 cubic yards including the fill placed by local interests. Out of the 133,000 cubic yards lost annually in the entire reach, 17,000 cubic yards are from Haulover Beach Park.

2.68 Local conditions. A considerable amount of the local fills apparently erode rather quickly under wave attack from the southeast; littoral drift generally is north to south with a seasonal northerly drift that moves the material both offshore and also southerly along the adjacent beach. Subsequent behavior of those beach fills indicates that limited amounts of beach nourishment, placed at 2-to-3-year intervals without first restoring the beach, provide only a temporary beneficial effect. There is now little or no protective beach at mean high tide throughout the project area, as indicated in figures 2 through 5.

2.69 Fishes. The Atlantic Ocean off the southeast coast of Florida offers a wide range of habitat for salt water fishes. In this area, the ranges of many tropical and subtropical species overlap those of the more typical forms of the south Atlantic coast, giving the area a rich and diversified ichthyofauna. Fish species inhabiting or visiting the area probably number in the hundreds, many of which are quite important from the commercial standpoint. The area is well known for its offshore sports fishing with nearby marinas providing a base of operations for many of the sports fishing and pleasure boats (paragraphs 2.07-2.16). A list of the more common species is presented in appendix B.

2.70 Invertebrates. Invertebrates known to occur in the intertidal zone of the project area include several species of polychaetes, the coquina shell, Donax variabilis; mole crab, Emerita talpoida; a variety

of amphipods and isopods; and a rich interstitial microfauna. Offshore, in the proposed borrow area and its environs, organisms recorded during biological surveys of sandy sediments and reefs (appendix A) included representatives of taxa listed in appendix B.

2.71 Analysis of grab samples from sandy bottom between reef rock showed that offshore sediments contain a fairly rich and diverse invertebrate fauna. At four stations, population densities had a range from 1,710 to 14,003 organisms/m^2, and the average was 7,321. At a fifth station, north of and outside the proposed borrow area, an even greater density of infauna was found. There, the number of invertebrates/m^2 amounted to 26,225.

2.72 Polychaetes and nematodes were the dominant organisms found in both areas, and in samples from the borrow area they accounted for more than 60 percent of the invertebrates collected. Syllids were the most commonly recorded bristle worms, and also found were members of the families Dorvilleidae, Eunicidae, Glyceridae, Lumbrinereidae, Onuphidae, Opheliidae, Orbiniidae, Oweniidae, Sabellidae, and Sigalionidae. Other invertebrates found in large numbers included the lancelet, Branchiostoma caribaeum; several mollusks, and a variety of small crustaceans--including juvenile stages of commercially important penaeid shrimp. In general, the infauna data showed a trend toward increasing invertebrate species richness and density from south to north. This observation may be a reflection of station-to-station changes in sediment texture and other factors.

2.73 Observations by SCUBA at five reef stations between Government Cut and Bakers Haulover Inlet showed that limestone terraces seaward of the 30-foot depth contour support a rich octocorallian fauna, but living madreporarian, or hard corals, were rarely seen and small in size. Furthermore, there was an evident deficiency in numbers and kinds of organisms that normally comprise a flourishing reef community. The fish fauna was sparse. The only conspicuous alga noted was Dictyota sp. Macroinvertebrates included a few sea urchins, sponges, anemones, mollusks, tubicolous polychaetes, arthropods, and ascidians. As a regional trend, reefs in the northern part of the project area exhibited greater relief (six to eight feet in small patches), and a more natural reef fauna than those at stations nearer Government Cut. Even so, all reefs examined in the project area appeared to be in far poorer condition than those observed at a sixth dive station located just north of Fowey Rocks Light. On the basis of published reports, it is apparent that reefs offshore from Miami Beach are also much poorer than those found as far north as Jupiter Island (Thompson, 1972; Smith, 1971, Opresko, 1973; Courtenay et al., 1974).

2.74 Marginal sea water temperatures and natural sedimentation may limit growth of hermatypic corals in the Miami area to some extent (Smith, 1971). However, as suggested by Straughan (1972), and others, turbidity and siltation from dredging, and pollution from municipal, industrial, and agricultural sources may be contributing or controlling causes of regional mortality among stony corals in recent years (Stoddart, 1969; Opresko, 1973; Yonge, 1973; Courtenay et al., 1974).

2.75 Wildlife. Other animal life is rather limited due to the highly developed nature of adjacent lands. Shore birds such as gulls, terns, sandpiper and brown pelican may be seen in the area. The only rare or endangered species known to occur in the area is the brown pelican.

2.76 Vegetation. There is little or no natural vegetation in the highly developed reach of the project area except for public park areas such as Haulover Beach Park. Mangroves in the project vicinity are present only at Interama site on Biscayne Bay. Native grasses, primarily broomsedge, common bermuda, and seashore paspalum occur in park areas. Tree species found in the park areas include Australian pine, coconut and sabal palm, palmetto, palmetto scrub, and baccaris shrubs.

2.77 Future prospects without the project. The existing process of beach erosion and undermining of protective structures would continue in the absence of the project. Shorefront property owners probably would continue to repair protective structures, to the economic benefit of contractors and construction personnel, and at the cost of materials and labor. New structures would be subject to permit approval under Section 10, River and Harbor Act of 1899. Sand, a natural resource, will continue to be lost from beaches to offshore areas. Capital improvements in the form of buildings and recreational structures would continue to be threatened and damaged. The project area's basic asset, the beach, would be of minimum usefulness, and public access to the beach would remain severely limited by existing groins. The storm wave protection afforded by an expanse of gently sloping beach would continue to be unavailable. Shorefront property owners would continue to seek Federal assistance in shoreline protection and emergency relief in the wake of hurricane damage. If water pollution and sediments were controlled, the coral reef community should flourish and provide the basis for the continuance of the valued sport fishery and for natural offshore protection.

3.00 Relationship of the proposed plan to land use plans. For regional and State land use management and planning the State of Florida Coastal Coordinating Council has produced a Florida Coastal Zone Management Atlas. The atlas contains county maps showing areas already developed and classifying coastal areas into three categories (zones) to reflect suitability for future development and present use. The categories are:

Preservation - no development suitable
Conservation - carefully controlled development is suitable
Development - intensive development is suitable

"Conflict areas" are labeled to show those zones that would have been classified preservation or conservation had they not already been developed. The project area is a "conflicting area" concerning which the State's stated objective is to encourage compatible use and discourage future development that does not recognize and adequately neutralize the environmental conflicts involved.

3.01 The Metropolitan Dade County Planning Department is preparing a three-part Comprehensive Development Master Plan for Dade County. Part One, Metropolitan Development Policies and Part Two, Environmental Protection Guide, have been completed. They will guide the preparation of Part Three, Metropolitan Development Guide. Present environmental objectives include (1) preserving the remaining functioning natural areas in Dade County; (2) insuring that urban development will neither infringe on the natural areas directly nor adversely affect adjacent areas such that the natural areas would be prevented from functioning properly; and (3) establishing a balance between urban natural resource demands (e.g., water) and natural area resource demands. The Metropolitan Development Guide (Part 3) will be composed of a "medium-range" (to 1985) and a "long-range" (to 2000) plan indicating recommended population densities, land use patterns, transportation facilities and extent of urbanization. The Environmental Protection Guide (Part 2) cites the proposed beach erosion control project as a present obligation necessitated by past unwise developmental procedures. The Environmental Protection Guide provides a basis for directing land use patterns to protect remaining undeveloped beaches and associated coastal zones from the developmental patterns which have made this beach erosion control project obligatory. The completed parts of the metropolitan Dade County plan and the State management guide are complementary and the proposed project is supportive to both.

4.00 The probable impact of the proposed action on the environment. The partial restoration of the beach by placement of about 14 million cubic yards of sand will reestablish a wide public recreation beach and provide protection against hurricane surges and resultant destruction of seawalls protecting residential and commercial property. Esthetic characteristics would be enhanced by restoration of a wide sandy beach, covering of unsightly groins, and formation of a longitudinal dune, reminiscent of natural conditions. The project will not adversely affect other Federal or non-Federal projects in the area.

4.01 Public use. Groins which now limit public use of the beach will be covered by the added sand. The result will be more beach area available for public use. Recreational use of the beach will, however, be restricted sequentially in five segments during fill placement every 3 to 5 years. The work will be accomplished in segments to reduce inconvenience.

4.02 Turbidity and sedimentation. Silt and sediment stirred into suspension by dredging and fine material washed from beach fill will cause suspension of particles over each section of the sequentially

sectioned project length. The suspended material will be subjected to eddying and rotary currents and probably distributed over most of a section's area between beach and borrow sites.

4.03 Benthic invertebrates. Offshore invertebrates are considered here under two groups: sandy bottom organisms and organisms of coral reef communities. Bottom organisms sampled on 8 February 1974 are listed in appendix A (table A-1). The invertebrate fauna of the sandy areas between reef ridges may be characterized as rich in number of species. Without supporting information, the assumption made here is that fauna of borrow sites are comparable in composition to those sampled.

4.04 Organisms populating the borrow sites will be removed or driven from the sites. Motile invertebrates will begin to repopulate the sites after about nine months (Courtenay, et al., 1974). Inter-reef organisms will be directly unaffected by dredging. The motile beach invertebrates will repopulate replenished beaches by burrowing upward and by lateral movement. The common mole crab is known to re-establish its original population level within 2 or 3 days after beach nourishment (Hayden and Dolan, 1974).

4.05 Impact assessment on coral reef communities is based on the following information.

4.05.1 Dredging operations have damaged reef corals with sediment up to a minimum distance of 400 m. (436 yards) from dredging sites, and mechanical damage to reef corals has been inflicted apparently by dredge heads dragged across the reefs (Courtenay et al., 1974).

4.05.2 Reef coral communities in the project area presently show signs of stress, including the death of portions of some colonies, due to the direct (silt blanketing) effects of dredging in Government Cut.

4.05.3 The reef coral communities in the area are dominated by species tolerant of lowered illumination, such as that in turbid waters (Goldberg, 1973). Extension of the beach seaward, fines from the renewed beach, silt and sediment from dredging operations, and eddying and rotary currents will impose additional direct and indirect stress on reef coral communities on all three reef ridges. The stresses probably would be lethal to any scleractinian (hard) coral colonies within a 400-meter-radius of dredging operation.

4.06 Those reef communities on the outer reef slope (third, or seaward reef) growing at a depth of 20-30 m. (65-100 feet) and on the fore-reef at depths greater than 30 m. (100 feet)will be most affected by turbidity and sediment fallout. Eight species of scleractinians (hard corals) and 5 species of gorgonians (soft corals) form the basis of the community there and the community composition is that of one stressed by low illumination (Goldberg, 1973). Sediments from spills or overflows could cause the death of parts of hard corals up to 400 m. from dredging operations.

4.07 The expected stress upon or elimination of some of the scleractinian component of the reef community would change the complex of plants and animals forming the community. Gorgonians (soft corals) will survive (Courtenay et al., 1974) and a different sort of reef ridge community will develop where hard corals are killed. Those portions of the coral reef where colonies are killed will be subject to repopulation by neighboring coral colonies competing for the newly opened space (Porter, 1974). Appendix B contains a list of species and expected impacts on species.

4.08 The potential for the occurrence of this impact will be reduced by careful control of dredging operations. Borrow areas will be surveyed and precisely marked under supervision of the Army Corps of Engineers, and dredge operations will be monitored for adherence to standards.

4.09 Fishes. Fishes will be driven from around the borrow sites during dredging. The sports fishery will be partly disturbed by dredging and by turbid waters in each section as it is worked.

4.10 The changed character of the reef community, including the killing of part of the scleractinian coral colonies, could change the pattern of fishing area locations as the reef community reorganizes in new patterns of species relationships around new reef structural patterns. Strictly reef-associated fishes will be reduced in numbers as reef habitat is reduced. Much of the sport fishery, including the king mackerel fishery, will be essentially undiminished.

4.11 Rare or endangered species. The brown pelican is the only rare or endangered species known to inhabit the project area. It is not reported as nesting in the vicinity (Williams and Martin, 1970) and should not be adversely affected by the project. No upland wildlife habitat or vegetation will be disturbed by the project.

4.12 Historic sites or relics. The National Register of Historic Places has been consulted and no National Register properties will be affected by the project. A copy of the draft statement has been sent to the Florida Historic Preservation Officer for comments. A magnetometer survey will be conducted prior to dredging operations in the borrow area to detect the presence of objects of potential interest, and discoveries will be reported to the State Division of Archives, History, and Records Management for disposition.

4.13 Sand fill. Silica sand on the Florida east coast is that which historically has been carried down to the sea by the Savannah, Altamaha, and other rivers of Georgia and the Carolinas, and gradually shifted southward by shore currents and wave action. (We have no data upon which may be based conclusions about the effects of dams upon the supply of such sand and believe that such an issue is beyond the scope of this study.) Due to the geological history outlined, the underlying material of practically all the beaches contains a large portion of a sand and shell mixture of loose or unconsolidated sedimentary form which was deposited during the later stages of emergence. Surface sand samples were obtained from the dune, the backshore, the foreshore, and at -3,-6,-12,-18, and -30 feet, mean low water, on 9 representative profiles at Dade County during the 1964

Corps of Engineers Cooperative Beach Erosion Study. Median diameters of the samples obtained ranged from 0.13 to 0.84 millimeter. Average median diameter of samples along the backshore ranged from 0.38 to 0.47 millimeter; average median diameter of samples collected along the foreshore ranged from 0.35 to 0.48 millimeter; average median diameter at -18 feet was 0.36 millimeter. The sand was considered suitable for beach fill and would involve no adverse impacts.

5.00 Probable adverse environmental effects which cannot be avoided. Turbidity and sedimentation will occur during construction, affecting water quality and marine life. Benthic populations in the borrow areas will be removed and those in the beach fill areas will be covered or driven away. Similar populations will recolonize the area. Some hard corals in the area will be killed along with sessile organisms and communities associating with hard reef corals. This can be mitigated by concentrating borrow areas in several small areas, thus enhancing survival chances of reef corals in selected parts of the project area.

6.00 Alternatives to the proposed action.

6.01 Extension of jetty sealing. Consideration was given to seaward extension of the existing seal on the north jetty at Government Cut. The jetty was made sandtight for 450 feet in 1959-1960.

6.02 Further extension was requested by the city of Miami Beach and Dade County. Due to the very low rate of littoral drift material reaching Government Cut and the low shoaling rate in the inlet, respectively, estimated at less than 20,000 and 10,000 cubic yards annually, seaward extension of the seal is not considered necessary at this time. Adverse environmental impacts would consist mainly of the destruction of benthic habitat and organisms in the immediate area where the work is being performed.

6.03 Sand-transfer plant. Provision of a transfer facility at Bakers Haulover Inlet was considered in the study that led to the existing navigation project there (House Document 189, 86th Congress, 1st Session) and also in the beach project study. Due to the low littoral drift rate, estimated at 30,000-40,000 cubic yards annually, a sand-transfer plant at the inlet was determined to be more expensive than alternative means of achieving comparable benefits. Adverse environmental effects involved in the alternative would consist primarily of the destruction of benthic habitat and organisms in the dredged area.

6.04 Bay sand source. Obtaining required project fill from Biscayne Bay was considered. This is not desirable since dredging operations in the productive estuarine shallows may be excessively destructive to estuarine productivity, and bay materials are unsatisfactory for beach nourishment.

6.05 Upland sand source. Bringing fill from the mainland by truck was evaluated. Hauling costs and those of borrow-pit acquisition are prohibitive. The adverse environmental impact of this action would be the destruction of terrestrial habitat and organisms in the area from which fill is taken.

6.06 Other project material. Consideration was given to the possibility of utilizing material from nearby navigational projects for initial fill or maintenance. If at the time the project is implemented there are such projects in progress and if the dredged material is suitable, the possibility of making use of the material will be studied.

6.07 No action. If the project is not implemented, or alternative means employed, the beach erosion problem will continue unabated and shore development will continue to be susceptible to hurricane surge damage, resulting in continuing and increasing damages and expensive piecemeal control measures. Sand will continue to be lost from beaches to offshore areas, thus reducing a public recreational resource. The project area's basic asset, the beach, will be of steadily decreasing usefulness and the existing groins will continue to impede access to the remaining beach. The storm surge protection afforded by the proposed plan would not be realized. Shorefront property owners will continue to seek Federal assistance in shoreline protection and emergency relief in the wake of hurricane damage.

6.08 A modification of the "no action" alternative would be to combine it with active measures to protect the beach from development and the offshore area from pollution. Such a program, which has been described as letting nature take its course (Anonymous, 1974), would involve prohibiting any building within a specified distance from the shoreline or any structures or work programs on the beach or in adjoining waters designed to interrupt or control the natural operation of currents, tides, or waves. Existing structures would either be removed or abandoned and allowed to disintegrate. Since not all of the problems experienced in the project area are generated locally, the "no action" plan would have to be supplemented by adoption of similar development and pollution restrictions along a large share of the Florida coastline in order to be effective. Should that be accomplished, coral reef communities could be expected to rebuild along the patterns imposed by natural conditions, beaches would resume natural cycles of accretion and depletion, and the losses to flora and fauna attributable to the proposed dredging and filling project would be avoided. This alternative would be compatible, at least superficially, with State attempts to preserve untouched natural coastal areas through laws, voluntary action, and land purchase programs. However, since the project area already is highly developed with considerable public, as well as private investment, the alternative does not appear to be practical without prohibitive cost in compensation and relocation of individuals and groups and in view of the hostility it would engender. In addition, the alternative would conflict with the Flood Control Act of 13 August 1968.

6.09 Closing inlet. Filling in Bakers Haulover Inlet (an artificial cut through the barrier island) and removing the existing jetties to allow maximum beach nourishment by natural accretion from littoral drift also was considered. However, the relative low rate of littoral drift along the reach is not considered sufficient by itself to replace erosional losses even with removal of the inlet. In addition, such action would bring strong objections from boat owners and fishermen. Also, filling in the inlet would adversely affect tidal circulation and flushing action of interior bay waters and the Intracoastal Waterway with resulting probable degradation of water quality. The inlet provides the only opening to the ocean between Government Cut at Miami and Port Everglades at Fort Lauderdale, a distance of 23 miles.

7.00 Relationship between local short-term uses of man's environment and maintenance and enhancement of long-term productivity. The project's purpose of providing more recreational beach and assisting in preventing erosion of the shore would benefit the general area in short-term use of the environment and enhance its value over the long term at the cost of long-term commitment to maintenance nourishment. Without restoration and protection, the beach would continue to erode and endanger upland development resulting in a long-term loss to the economy of the area.

7.01 The destruction of reef corals represents an unquantifiable loss in long-term productivity which must be balanced against probable project benefits.

7.02 Completion of the project and its continued nourishment to compensate for erosion losses would commit this section of beach to public use. Without the project, much of the project area will remain inaccessible as a recreational resource. As required by the Secretary of the Army, and also by State regulations, all of the project will be established as public beach prior to completion of initial construction. Coastal communities throughout the project limits are in the process of, or have completed, conversion of the project beach area to public ownership. They will also provide public access routes generally at one-half mile intervals to assure full public use of the improved beach.

8.00 Irreversible and irretrievable commitments of resources which would be involved in the proposed action. Reef corals and reef coral communities will be reduced in the project area. Other marine and shore life eliminated by construction operations would be irretrievably lost but the minimal amount affected and high rate of repopulation reduces the significance of the loss. The extent to which the project would assist in improving and protecting use of the beach for public recreational purposes represents a commitment lasting as long as the beach is maintained for that purpose. Labor to be used during initial construction and each subsequent maintenance period would also be an irretrievable commitment of resources.

9.00 Coordination and comment and response. The proposed plan of improvement was coordinated with all known interested agencies and groups in 1962, and it was explained at a public meeting in Miami on 5 March 1964. By letter of 23 December 1964, Dade County provided assurance that it would sponsor the proposed project on behalf of local interests. Further public meetings were held in Miami Beach on 3 October 1967, 11 June 1969, and 12 December 1974.

9.01 Public participation. The Southern Florida Hotel and Motel Association on 21 October 1967 submitted a statement initially objecting to the proposed plan of improvement. At a Miami Beach press conference on 13 October 1971, however, representatives of the hotel and motel industry as well as city and county officials publicly endorsed the shore protection project. The Surfside Civic Association by resolution of 21 December 1971 indicated its support of the project. By resolutions of 20 October 1971 and 15 February 1972, respectively, the remaining shorefront cities of Miami Beach and Surfside indicated their acceptance and support of the project. At the public meeting held in Miami Beach on 12 December 1974, concern was expressed by the National Audubon Society, Tropical Audubon Society, Florida Marine Aquarium Society, South Florida Divers Association, and Mr. Jay Briel, that implementation of the project would destroy the reefs in the area which would result in disruption in food chain relationship. The possible damages to the reefs is discussed in detail in paragraphs 4.03-4.11 and page 45. Also, appendix A contains a biological assessment of the borrow areas. Concerns expressed at the public meeting have been addressed in the Final EIS.

9.02 Government agencies. Comments were solicited from:

USDA - Soil Conservation Service
USDA - Forest Service
U. S. Department of Commerce
U. S. Coast Guard
U. S. Department of Interior
U. S. Environmental Protection Agency
U. S. C. E. Waterways Experiment Station
State of Florida, Office of the Governor
Florida Department of Pollution Control
Florida Department of Administration,
Division of State Planning
Florida Department of Transportation
Florida Department of Community Affairs
Florida Department of Health and Rehabilitative Services
Florida Historic Preservation Officer

Comments received from these agencies and responses to comments follow.

a. Federal agencies.

(1) USDA - Soil Conservation Service

Letter of no comment received.

(2) USDA - Forest Service

Letter of no comment received.

(3) U. S. Department of Commerce.

Comment: Inclusion of the estimated width of fill needed to form "natural seaward slopes" below the 70-foot width of the dune and berm would increase the informational content of the statement. Plans to establish dune vegetation should also be considered. Beach plantings have had some success in other areas and have been included as integral parts of other nourishment programs.

Response: Dimensions of all fill structures to be formed are given in paragraph 1.01. Natural seaward slopes will be formed by wave, tide, and current action. Dune vegetation establishment is not contemplated. The intensive recreational use and policy of unrestricted public access precludes the restriction of use which would be necessary for establishment of vegetation.

Comment: The proposed offshore borrow sites should be identified and described in greater detail. Minimum data should include:

a. Location of reefs,
b. isopachs of available sand, and
c. Quantity and sedimentary characteristics of available sand.

The information on isopachs is available from the Corps of Engineers.

This section would also be enhanced by including a description of the type and alinement of cuts (i.e., whether they will be deep pits or shallow trenches).

Response: This information is presented in appendix E.

Comment: The statement does not mention the contribution of rising sea level to the serious problem of beach erosion. According to the National Ocean Survey's most up-to-date measurements and calculations, sea level has been rising relative to the land at an average rate (least square on annual means of 2.50 mm/yr (+0.29 mm/yr) from 1932 through 1972 at Miami.

Bathymetry information available from the National Oceanic and Atmospheric Administration - National Ocean Survey (NOAA - NOS) should be included.

Also, a five-month program of current measurements and other physical oceanographic measurements just seaward of Miami Beach within the project area has just been completed. This is a joint effort by NOAA's Atlantic Oceanographic and Meteorological Laboratories (Miami), the Rosenstiel School of Marine and Atmospheric Science (University of Miami), and Nova University (Fort Lauderdale). There were eight

anchored current meter buoy stations in water depths between 20 and 100 feet with two or three meters at the deeper stations and one at the shallower ones. Meters were regularly replaced by divers so that continuous records for periods up to five months are available. The field phase was completed in early August of 1974, and the data are still being reduced for analysis. It is urged that the Corps of Engineers review the status of this project and include in their statement such relevant information as is then available.

Response: The phenomenon of rising sea level is of a scope and scale beyond that of the project and this statement. Information on current studies has been expanded in paragraphs 2.43 through 2.50.

Comment: Considering that the project is proposed as a hurricane control measure, we suggest that the statement evaluate the success that beach renourishment programs have had elsewhere in preventing or diminishing damage from hurricanes.

Response: Sufficient information to evaluate such man-made protection efforts has not been developed. However, observation of natural beaches suggests that the presence of an expansive beach with a gentle seaward slope does afford protection.

Comment: This section should note that seawalls and groins have been ineffective in controlling erosion, and probably cause some erosion. Groins and jetties block the drift of sand, whereas seawalls and similar structures accelerate erosion by vectoring wave forces downward, thus carrying away sand and leaving a channel into which the structures themselves may eventually fall.

Response: Paragraphs 2.51 through 2.56 note the problems associated with groins and jetties and erosion processes.

Comment: Is the figure of 158,000 cubic yards the average annual erosion rate?

Response: Yes.

Comment: The statement should describe what is meant by "...partially restoring the problem beach."

Response: The statement (paragraph 2.61) has been revised.

Comment: The statement should include an in-depth description of recreational and commercial fishing activities within the area. Fishing piers and reefs within the project area should be identified. Plans proposed to minimize damages to fish from pumping, dredging, and filling activities should be described. A survey of recreational fishing activities in the project area is presented by Moe (1970).

Response: The statement has been expanded to discuss fishing activities (paragraphs 2.07-2.13).

Comment: A description and delineation of reefs and reef rocks should be presented.

Response: This is accomplished in paragraphs 2.02-2.04.

Comment: Turtle grass (Thalassia) beds are common on the bottom immediately south of the project area and play a major role in the nearshore sedimentary regime, yet there is no mention of the presence or absence of Thalassia in the project area.

Response: Thalassia is not present in the project area (appendix B).

Comment: Mention should be made of the public access aspects subsequent to the beach replenishment. This was a problem during the early negotiation stages, and the history and solution of this problem should be included to preclude the problem being brought up again.

Response: This has been done: paragraphs 1.03, 1.04, and 4.02.

Comment: Whereas investigations indicated that reef communities in the vicinity of the project are deficient in numbers and kinds of organisms, the statement might also consider that project activities could severely diminish the recovery capabilities of these communities. Descriptions of the monitoring procedures and the dredging and pumping methods should be included.

Response: Effects on the reef community are discussed in paragraphs 4.06-4.08. Mitigation procedures and effectiveness are discussed in paragraph 4.09.

Comment: References should be given for those studies or authorities supporting the conclusion that repopulation "...will occur soon after project completion." Bottom sediments in borrow pits offshore of Pinellas County (Florida West Coast) were extremely soft and silty and virtually devoid of macroinvertebrates soon after project completion.

Response: References are cited (paragraph 4.05) and discussion of impacts and recovery expanded (paragraphs 4.07, 4.08, and 4.10).

Comment: The median diameters of sediment particles in samples taken at 30-foot contour should be included. A description of sedimentary characteristics at the 40- and 60-foot depths also should be included since these are the depths from which sand is to be "borrowed."

Response: Descriptions of borrow materials are presented in paragraphs 2.42 and 2.43, and in appendix E.

Comment: There is no indication of the depth of the excavation that will remain on the sea floor after the offshore borrow pits are abandoned. Modification of the sea floor will affect the local wave regime, yet there is no mention in the statement of possible shoreline effects from the focusing of wave action or the modification of longshore drift patterns due to this modification of the local bottom topography.

Response: Previous studies (Courtenay, et al., 1974) show that the dredged sites are refilled with transported sand.

Comment: This section should identify any existing supplemental sources of sand that could be obtained from maintenance dredging or other similar activities within the project area.

Response: Sources are discussed in paragraphs 6.02-6.05.

(4) U. S. Coast Guard

Letters indicating no conflicts with Coast Guard mission were received.

(5) U. S. Department of the Interior; Office of the Secretary

Comment: This section indicates that Golden Beach is a bathing beach for residents of Golden Beach only. If the area is publicly owned, it should not be restricted to Golden Beach residents. The presence of groins and seawalls mentioned in Section 2.10, Public Access, effectively preventing public use of the beaches, should also be taken into account in assessing the public benefit from the proposed project.

Response: The issue of public access is discussed in paragraphs 1.03, 2.37, and 4.02.

Comment: The statement discusses a reef survey made by scuba divers in the Miami Beach outer reef area, and compares the data obtained to an area near Fowey Rocks. We presume that Station 6 of Table 1-2 corresponds to the Fowey Rocks station. The decreasing numbers of organisms and species diversity from north to south within the study area, reported in Sections 2.35 and 2.36, may be correlated with siltation from dredging in Government Cut, as described in appendix 1, under the Reef Survey heading. Therefore, Section 3.02, Turbidity and Sedimentation, which states that "...reef communities in the general vicinity of the project are deficient in numbers and kinds of organisms found in reef ecosystems north of the project area," appears to be justifying additional impact on stressed reef areas because of the reduced animal populations and diversity, when this reduction may be the result of ongoing dredging activities in the vicinity. The statement should discuss further the cumulative effect of prior environmental modifications, and the proposed work, upon the stressed reef areas.

Response: This issue is discussed in expanded form in paragraphs 2.04 and 4.04-4.07.

Comment: The statement would be improved by mention of whether the material to be dredged is polluted and, if so, a discussion of the effects of this condition should be included.

Response: The material is not polluted.

Comment: The report assumes reestablishment of marine organisms through natural proliferations after adverse environmental effects have worn off. Previous reef studies carried out indicate this is not the case; reefs in weakened condition do not provide basis for regenerating organisms but gradually worsen and die.

Response: This is discussed in paragraphs 4.06-4.08.

Comment: We note that the Florida Historic Preservation Officer will be consulted. A copy of his comments should be included in the final report. The National Register is in an early state of development and under Executive Order 11593 and the Procedures for Compliance with the Historic Preservation Act of 1966 as published in the Federal Register of January 25, 1974, required the Federal agency to identify and to place in nomination to the National Register those sites that may be affected by the projects. It is incumbent upon the Corps to carry out such a study. In addition, the Corps should check with the Florida Historic Preservation Officer regarding any places that he may have in the process of nomination to the National Register of Historic Places.

Response: As stated in paragraphs 9.03 and 9.07, comments from the Florida Historic Officer were solicited. None was received.

(6) U. S. Environmental Protection Agency

Comment: We have reviewed the Draft Environmental Impact Statement for the Beach Erosion Control and Hurricane Protection Project in Dade County, Florida (between Government Cut and Bakers Haulover Inlet) and are concerned about some of the environmental consequences of the proposed action. Furthermore, we do not believe the benefits of the project will outweigh the environmental damage, and urge that further consideration be given to the suggested alternatives.

Response: Section 6, or alternative has been revised and expanded to provide as full and accurate analysis as possible. Cost-benefit analysis data are provided in appendix C.
Also see paragraph 1.03.

ENVIRONMENTAL INFORMATION CENTER
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935 ORANGE AVE • WINTER PARK, FLORIDA 32789 • TEL. (305) 644-5377

August 16, 1974

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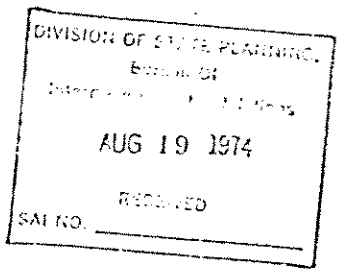

State of Florida
Department of Administration
Division of State Planning
660 Apalachee Parkway
IBM Building
Tallahassee, Florida 32304

Attention: Ed Maroney

Dear Mr. Maroney:

The attached ENFO newsletter is being sent to you to cover most of our "comments" on SAI: 75-0113E.

We feel that the Impact Statement is inadequate for the following reasons:

1. Adequate environmental assessment of potential long-range effects from dredging offshore sands has not been made. Evidence exists that siltation from dredging has caused permanent and irreversible damage to corals and other benthic organisms.

2. An environmental assessment of the long-range effects from pumping offshore sands onto beaches has not been made. The enclosed study does not site evidence of studies to show that this operation will not serve as a contaminate to beach organisms.

3. The temporary nature of restoration benefits due to the limited quantities of compatable beach sand available has not been addressed.

Sincerely,

Susan Whigham

Susan Whigham
Secretary

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Comment: We are especially concerned about the effect that 10.5 miles of dredging will have on the unique reef system of the area, and find a need for additional information on this aspect of the project in order to assess fully the environmental impact.

The statement notes that the reef system is under extreme stress; however, it is indicated that because of this condition the dredging of a 3,000 foot-wide strip beginning at 6,000 feet offshore, is justified.

We believe, on the contrary, that such action will degrade or destroy what reef life is left, and that every effort should be made to protect it. This Office, in its exhaustive "Ocean Outfalls and Other Methods of Treated Wastewater Disposal in Southeast Florida" (March 19, 1974) also presents documentation that the reefs are under extreme stress and went to great lengths to preserve them. In view of our findings in this report, we do not look favorably on a short-term project that would have such serious long-term effects on the biota.

As to specific comments on the Statement, we offer the following:

1. There are several deficiencies in the reports on visual locations at five locations along the reef. First, we believe that limiting the observations to only five stations is inadequate for an accurate description of the reef. It also would be helpful to know: (a) who did the observing and their qualifications for assessing its state of being, and (b) the location of the reef(s) in relation to the proposed dredging area.

Response: Additional information is presented in paragraphs 2.02-2.04 and 4.06-4.08. (a) The observations were made by a contractor determined to be qualified (appendix A). (b) Reef locations are generally indicated in relation to borrow areas on plate 1.

Comment: Since the reef at Station 1, which is about one mile from Government Cut, showed evidence of stress from dredging in Government Cut (page 1-5), we believe that additional studies should be made to determine the area of influence of the dredging, and the minimum distance from the reef that dredging should be done.

Response: The study recommendation is for a minimum distance of 400 m (436 yards) from reef corals (paragraphs 4.06).

Comment: Appendix 1 states that qualitative and quantative information on regional distribution of benthic organisms is useful in selecting operational sites that would cause minimum environmental damage. We suggest that a five-mile stretch without a station (page 1) would not give much information on the bottom within that area.

Response: The cited study is supplemented with information from a more detailed, nearby study, discussed in paragraphs 2.03 and 2.04.

Comment. Identification of the macroinvertebrates collected on February 8, 1974, and given in table 1-1 leaves much to be desired. Identification to the generic or specific level, especially those organisms making up the larger part of the community (i.e. polychaetes and molluscs), would add much to the discussion of density and diversity.

Response: A study of the comment level of detail has not been made, except for that cited in paragraphs 2.03 and 2.04.

Comment: It is stated (page 33) that the benthic community will return to normal following completion of the project. However, no mention is made of how long this will be. We recommend expansion of this topic in the final statement, preferably with reference to studies that have been conducted and documented.

Response: The topic has been expanded in paragraphs 4.04 and 4.08.

Comment: Information should be provided on the probable makeup of the surface substrate in the borrow area once sedimentation has ceased. If dredging is to be continued every two to three years, the inevitable result will probably be destruction of life in the coral reef, and the organisms in the borrow area will be limited to those capable of living in silt and not adversely affected by turbidity. Fishing in this area would suffer as a result of a decrease in fish food.

Response: The substrate will be replenished with sand by littoral drift, and recovery of invertebrates and of the fishery are discussed in paragraph 4.04-4.09.

Comment: We note that the benefit-cost ratio for the 0.85 segment of the project south of and adjacent to Bakers Haulover Inlet (EIS, November 1972) was 1.1 to 1.0 at 5-3/8 percent. However, the benefit-cost ratio of the present project is 1.7 to 1.0 at an unknown interest rate. It would be helpful to know how this is made up, and we recommend that the final statement include this information.

Response: Benefit-cost data are presented in appendix C.

9.03 State agencies.

(7) Department of Administration, Division of Planning (Clearinghouse)

Comment: The enormous public cost of the project should serve to justify additional public beach access.

Response: Such access is assured by contractual agreement (paragraphs 1.03 and 1.04).

Comment: The dredge site is not adequately defined as to size, shape, location, etc., and should be so defined in the final environmental impact statement.

Response: Borrow sites are more precisely defined in revised plate 1.

Comment: Adequate environmental assessment of potential long-range effects of initial and recurring offshore dredging has not been made. In particular, the effect of increased turbidity on reefs to the north and south should be carefully evaluated.

Response: Expanded environmental discussion is contained in paragraphs 4.01-4.13.

Comment: Projected resident and tourist populations are not supported and may be discrepant in light of current economic conditions.

Response: Source of the data is Miami Beach Chamber of Commerce published document.

Comment: Proposed borrow areas are in -40 to -60 feet of water. In section 3.06 the deepest sample was taken to -30 feet. There is no evidence to indicate that the grain sizes of the proposed borrow area would be suitable to the sub-aerial and breaker zone of the new beach.

Response: Additional studies have been made of materials in the selected borrow sites and are reported in paragraphs 2.39 and appendix E.

Comment: The fact that reef communities at the work area are different in numbers and kinds of organisms than those found in reef ecosystems north of the project area, does not mean the impact of adverse effects would be reduced. If anything they are accentuated since the community is smaller but still subject to the same stress.

Response: This is discussed in paragraphs 4.05-4.08.

Comment: Median diameters do not give an adequate representation of the sediment. Grain size distribution should be shown.

Response: This is shown in appendix E.

Comment: There is no indication that the sand in the proposed borrow areas is suitable for beach fill. Data for present beach sand (taken in 1964) and a sample from -18 feet do not constitute data for the borrow areas.

Response: Additional studies have been completed (paragraph 2.39). Data for the borrow site are presented in appendix E.

Comment: Grain size distribution and data for all samples plus data and grain size distributions for samples taken from proposed borrow areas should be included in the final Environmental Impact Statement. Also, the number of sampling stations should be increased.

Response: These are reported in appendix E.

Comment: Turbidity and siltation can kill many reef organisms, especially sessile organisms. More information is needed on suspended materials, duration of dredge operation, and transport of suspended materials out of dredge and fill areas and amount of sedimentation.

Response: These questions are addressed in paragraphs 1.02 and 1.03. Amount of sedimentation is not quantified.

Comment: The project will only enhance the value of the area in the short-term as artificial maintenance will be necessary in the long-term. On the other hand, the repopulation time for many of the corals would be long-term as they need a hard surface on which to attach themselves and these surfaces would be silt-laden as a result of dredging.

Response: This is discussed in paragraphs 7.01 and 7.02.

Comment: The following alternative should be evaluated: reinforce seawall where needed, construct limited public beaches by limited pumping around areas of presently good groin fields, and remove groins from areas not designated public beach to maximize littoral drift.

Response: Extensive public beach would be constructed by the project, groins would be covered, and interference with littoral drift by structures would be prohibited. Seawall reinforcement, however, is not part of the project.

Comment: The benefit-cost ratio should be substantiated and as a minimum should include the costs of long-term environmental degradation, recurring maintenance dredging and restoration, and possible reduces benefits due to recent economic trends.

Response: Benefit-cost data are supplied in appendix C.

Comment: In accordance with the Council on Environmental Quality guidelines concerning statements on proposed Federal actions affecting the environment as required by the National Environmental Policy Act of 1969, and U. S. Office of Management and Budget Circular A-95, this letter, with attachments, should be appended to the final environmental impact statement on this project. Comments regarding this statement and project contained herein or attached hereto should be addressed in the statement.

Response: This is done.

(8) Florida Department of Pollution Control

Comment: Turbidity will be difficult to control at the start of the project due to the lack of sufficient material at the disposal site to construct the necessary berms, dikes, etc., to provide retention of the liquid portion of the hydraulic dredge discharge and settling out of suspended fine sediments.

Turbidity at the dredge site, though not as great as at the spoil site, will be more difficult to control as conventional methods of control, i.e. diapers, are not practical in the water depths at the proposed dredge sites. Other means of controlling turbidity at the dredge sites may be necessary.

Response: This is discussed in paragraphs 4.03 and 4.09.

Comment: The reefs north of the project, in addition to those in the immediate vicinity, will be effected by turbidity and sedimentation produced by the dredging because of the predominance of north currents.

Reponse: Effects on reefs, including interaction with currents, are discussed in paragraphs 4.06, 4.07, and 4.08.

(9) Florida Department of Transportation

Letter of no comment received.

(10) Florida Department of Community Affairs

Letter of favorable action recommendation received.

(11) Florida Department of Health and Rehabilitative Services

Letter of favorable action recommendation received.

9.04 Citizen groups. Comments were solicited from the following organizations:

Save Our Bays, Inc.
Surfside Civic Association
Tropical Audubon Society

Additionally, the Florida Conservation Foundation, Inc., Environmental Information Center, contributed unsolicited comments.

(12) Tropical Audubon Society

Comment: The draft impact statement, in general, is based upon outdated studies. It is particularly noted that the sand and current study utilized was completed in 1936. (ref. paragraph 2.18). Since then, major modification of the beach area has taken place. Not only has beach rejuvenation been conducted, but the offshore region has changed - i.e. the 12-foot contour line has receded 282 feet (ref. paragraph 2.29) despite or possibly because of groin construction and emplacement. Additional encroachment of the beach area by hotel and motel construction has further reduced or removed entirely the potential source of natural sediment supply which previously existed.

Response: Additional studies have been completed and are reported in paragraph 2.39 and following paragraphs and in appendix E.

Comment: The offshore disposal of sewage via pipeline has been documented as being a major pollution hazard to bathers as well as benthonic and pelagic organisms. No mention of these reports is made, either as a past problem or as to the potential effects which may occur as a result of beach rejuvenation.

Response: No known reports on the subject are deemed relevant to this statement. Wastewater disposal conditions in the project area are mentioned in paragraphs 2.24-2.31.

Comment: There has been no relevant research of previous beach rejuvenation efforts during the past nourishment periods. Was the beach sand carried offshore, down the coast and further south to Key Biscayne? Essentially, what has happened to it? What may happen to the pumped up sand after this proposed operation is completed?

Response: The research required to specifically answer these questions has not been done.

Comment: What will be done with the existing, deteriorated bulkheads? Will they be replaced, removed or simply covered? What about the groins, water pipes, sewage disposal lines, swimming pool drains? - will they be relocated or removed?

Response: As stated in paragraph 4.02, groins will be covered with dredged sand. Bulkhead treatment is not part of the project. Sewage disposal lines are not located within the project area. Swimming pool drains are not to be treated within the project scope.

Comment: Will the newly paced "dune" be stabilized with vegetation?

Response: The dune will be subjected to such intensive use that vegetation plantings would not survive. Also, the beach is maintained by motorized equipment to remove accumulation of seaweed and other debris. The county has indicated that the most feasible method for maintaining the hurricane surge protection would be by use of a motor patrol to periodically grade the dune to design elevation which would completely destroy any type of vegetative stabilization.

Comment: What about the offshore corals? Will they be totally disregarded and killed?

Response: It appears that those offshore scleractinian ("hard") corals within 400 meters of dredging operations will be killed. Some may be saved by concentrating dredging in certain selected sites in order to minimize sedimentation in part of the reef area.

Comment: The public access to the beach is hardly access. No new access areas are planned and it is obvious that the old access areas, including public property, does not include sufficient parking areas. Have local laws been strengthened as to encroachment of beach areas by construction? Do recent State decisions locating setback lines further inland have legal effect on artifically created beaches or do old standards apply?

Response: Local interests will establish and maintain public access to all of the new beach fill seaward of the present landward limit of the project, together with acceptable access and other facilities necessary for public use. See paragraph 1.03 of this statement.

Comment: There also exist numerous economic and legal questions. For instance, how was the cost-benefit ratio determined? The non-specific nature of the data needs clarification. What was the basis of computation and to whom do the "benefits" apply?

Response: Cost-benefit information is provided in appendix C.

(13) Florida Conservation Foundation, Inc.
Environmental Information Center

Comment: Adequate environmental assessment of potential long-range effects from dredging offshore sands has not been made. Evidence exists that siltation from dredging has caused permanent and irreversible damage to corals and other benthic organisms.

Response: This is discussed in revised paragraphs 4.03-4.11.

Comment: An environmental assessment of the long-range effects from pumping offshore sands onto beaches has not been made. The enclosed study does not site evidence of studies to show that this operation will not serve as a contaminant to beach organisms.

Response: This is discussed, with sources cited, in paragraph 4.05.

Comment: The temporary nature of restoration benefits due to the limited quantities of compatible beach sand available has not been addressed.

Response: More than needed quantities of sand suitable for beach fill is available (paragraphs 2.39-2.44 and appendix E).

LITERATURE CITED

Anonymous, 1974. Beach restoration: an exercise in futility. ENFO, July, 1974. Florida Conservation Foundation, Environmental Information Center, Winter Park.

Colhart, B. J., and H. W. Johansen. 1973. Growth rates of Corallina officinalis (Rhodophyta) at different temperatures. Mar. Biol. 18(1): 46-49.

Courtenay, Walter R., Jr., David J. Herrema, M. John Thompson, William P. Azzinaro, and Jacques van Montfrans. 1974. Ecological monitoring of beach erosion control projects, Broward County, Florida, and adjacent areas. U. S. Army Corps of Engineers, Coastal Engineering Research Center, Ft. Belvoir, Va. Tech. Memo. No. 1, 88p.

de Sylva, D. P. and L. N. Scotton, 1972. Larvae of deep-sea fishes (Stomiatoidea) from Biscayne Bay, Florida, U. S. A., and their ecological significance. Mar. Biol. 12(2): 122-128.

Florida, State of; Coastal Coordinating Council, 1972. Tallahassee.

Goldberg, Walter M. 1973. The ecology of the coral-octocoral communities off the southeast Florida coast; geomorphology, species composition, and zonation. Bull. Mar. Sci. 23(3): 465-488.

Hayden, Bruce and Robert Dolan. 1974. Impact of beach nourishment on distribution of Emerita talpoida, the common mole crab. Journal of the Waterways Harbors and Coastal Engineering Division. May 1974.

Kirtley, David W. 1967. Worm reefs as related to beach stabilization. Shore and Beach Journal, Amer. Shore and Beach Preserv. Assoc. 35(2): 31-34.

Knutson, David W., Robert W. Buddemeier, and Stephen V. Smith. 1972. Coral chronometers: seasonal growth bands in reef corals. Science 177(4045): 270-272.

Miami Beach Chamber of Commerce. Undated. Facts and Figures. Miami Beach Chamber of Commerce, Miami Beach.

Moe, Martin A. Jr. 1963. A survey of offshore fishing in Florida. Florida State Board of Conservation Marine Laboratory Professional Papers Series, Number 4.

Moe, Martin A. Jr. 1970. Florida's fishing grounds. Great Outdoors Publishing Company. St. Petersburg, Florida. 80 p.

Moore, Willard S., S. Krishnaswami, and S. G. Bhat. 1973. Radiometric determinations of coral growth rates. Bull. Mar. Sci. 23(2): 157-176.

Opresko, Dennis M. 1973. Abundance and distribution of shallow-water gorgonians in the area of Miami, Florida. Bull. Mar. Sci. 23(3): 535-558.

Roberts, Harry H. 1972. Coral reefs of St. Lucia, West Indies. Carib. J. Sci. 12(3-4): 179-190.

Smith, F. G. Walton. 1971. Atlantic reef corals. Univ. Miami Press. xii + 164p.

Stewart, R. E., H. E. Putnam, R. H. Jones, and T. N. Lee. 1970. Diffusion of sewage effluent from ocean outfall, in Proc. Civil Engineering in the Oceans. II, pp. 1151-1185. Am. Soc. Civil Engineering Conf. Miami Beach, Florida, Dec. 10-12, 1969. Am. Soc. Civil Engineers, New York.

Stoddart, D. R. 1969. Ecology and morphology of recent coral reefs. Biol. Rev. 44: 433-498.

Straughan, Robert P. L. 1972. Pollution, dredging decimating Florida's reefs. Natl. Fish. 52(13): 46-48.

Stroud, Richard H. Undated. Benefits spread far and wide. Sport Fishing, U. S. A. U. S. Department of Interior, Bur. Sport Fisheries and Wildlife.

Thompson, John R. 1973. Ecological effects of offshore dredging and beach nourishment: a review. U. S. Army Corps of Engineers, Coastal Engineering Research Center. Miscellaneous Paper No. 1-73.

Thompson, M. John. 1972. Coral, sponge, and gorgonian communities off southeast Florida mainland. Unpublished Manuscript, Dept. Biol. Sci., Florida Atlantic Univ. 37p.

U. S. Environmental Protection Agency, Region IV, Atlanta. 1973a. Environmental Impact Statement, Ocean Outfalls and Other Methods of Treated Wastewater Disposal in Southeast Florida.

U. S. Environmental Protection Agency, Region IV, Atlanta. 1973b. Final Environmental Impact Statement, South Dade County, Florida C120377.

Wanless, H. 1969. Sediments of Biscayne Bay--distribution and depositional history. Master's thesis. University of Miami Institute of Marine Science. 260 p.

Wennekens, M. P. 1959. Water mass properties of the Straits of Florida and related waters. Bull. Mar. Sci. Gulf Caribbean 9(1): 1-52.

Williams, Lovett E. Jr., and Larry L. Martin. 1970. Nesting populations of brown pelicans in Florida. Proc. Southeast Association Game and Fish Commission, Atlanta. 24:154-169.

Yonge, C. M. 1973. The nature of reef-building (hermatypic) corals. Bull. Mar. Sci. 23(1): 1-15.

Porter, James W. 1974. Community structure of coral reefs on opposite sides of the isthmus of Panama Science 186:543-545.